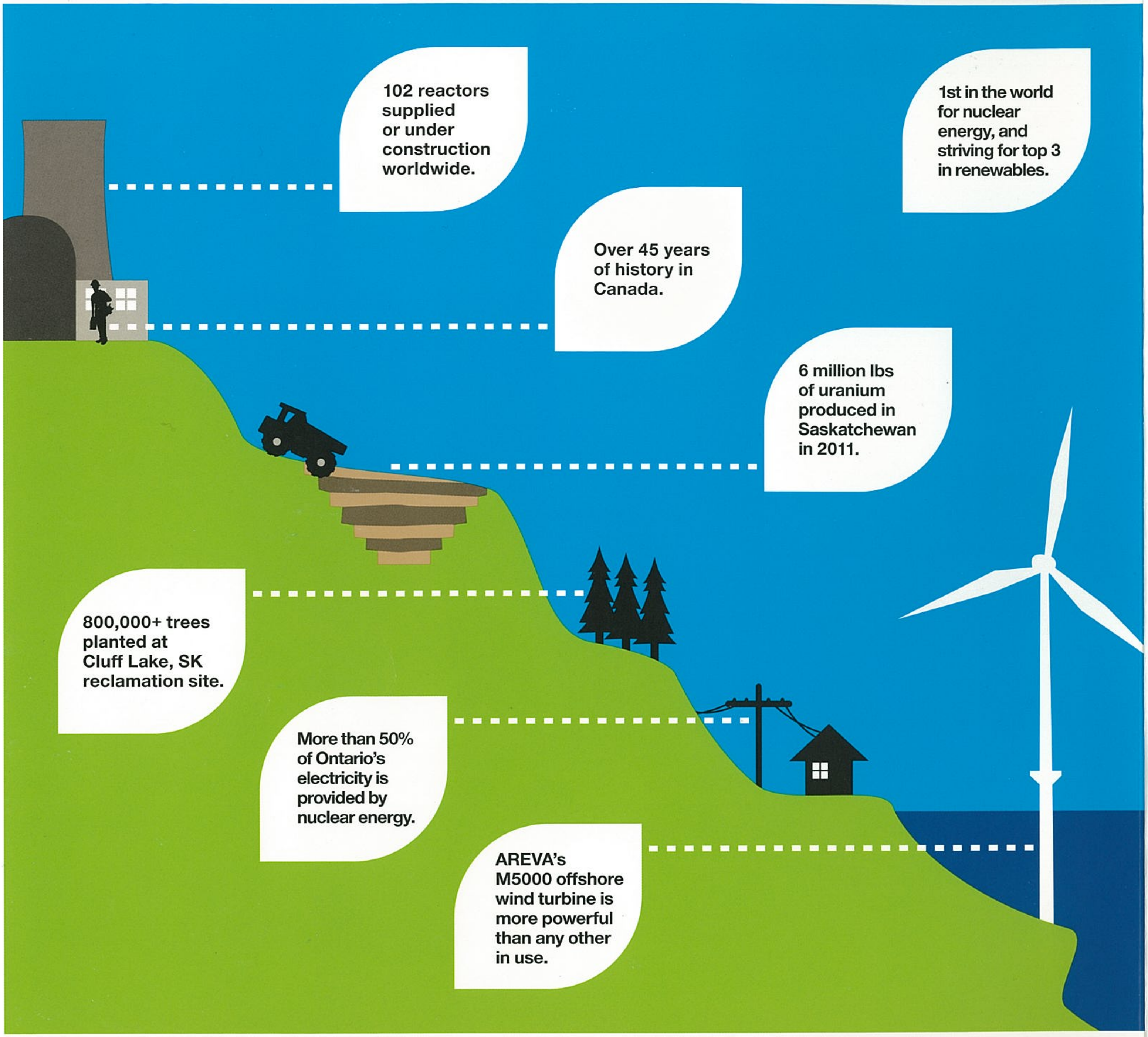
CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

SEPTEMBER 2012 SEPTEMBRE VOL. 33, NO.3

- Nuclear Outreach and Education Workshop
- Message from the President
- AECL Hosts Open House
- Rolls Royce Supplies Fuel Transfer System to AECL


102 reactors supplied or under construction worldwide.
1st in the world for nuclear energy, and striving for top 3 in renewables.
Over 45 years of history in Canada.
6 million lbs of uranium produced in Saskatchewan in 2011.
800,000+ trees planted at Cluff Lake, SK reclamation site.
More than 50% of Ontario's electricity is provided by nuclear energy.
AREVA's M5000 offshore wind turbine is more powerful than any other in use.

Gentilly-2 Be

The newly elected separatist government of Québec has announced that it will close permanently their only nuclear power plant, as they said they would do some two years ago if elected. Coincident with that announcement was the release of a documentary [sic] entitled "Gentilly or Not To Be". The film claims that children living in Trois-Rivières and Bécancour have higher rates of leukemia and congenital defects than average, citing the usual "German Study" as "proof". Dr. Éric Notebeart, a professor in medicine at the Université de Montréal said "I wouldn't have a young family within 10 kilometres of Gentilly-2, that's for sure". And not to be left out, anti-nuclear advocate Gordon Edwards has praised the Government's decision noting that it opens a "great opportunity" for Gentilly-2 to be transformed into a centre of expertise on dismantling nuclear power plants.

As for the anti-nuclear fear mongering, once again our regulator, the Canadian Nuclear Safety Commission has come to the rescue and dispelled the nonsense. And as a professor of medicine, Dr. Notebeart has proven his lack of medical knowledge given that residents near Gentily-2 get nearly 1000 times more radiation from natural sources than from the plant. It might be wise for his students to find another professor if they want a credible education.

As for Parti Québécois leader Pauline Marois, her decision is short sighted and politically motivated. Although at present electricity supplies are abundant, with about 97% from hydro dams, the supplies of hydro in Québec will be maxed out by 2020. There is no more First Nations caribou land to flood. Quebecers will regret the decision made by their politician to shut down Gentilly-2 when they are importing high cost electricity from its neighbours or burning expensive gas.

Gentilly-2 is not a major source of supply in Québec, but it is has strategic importance to stabilize their grid. Hydroelectric production is in the far north of the province whereas demand is in the south, meaning that the transmission lines are very long. Long lines are susceptible to harmonics, or large power swings that can be damaging including catastrophic turbine breakup – the reactor at Gentilly-2 helps control and suppress these power swings. Power swings can be caused by a sudden change in load, such as line failure or sudden shutdown of an industrial user, or natural phenomena such as lightning strike, ice storm or geomagnetic storm. The latter caused a complete collapse of the grid during a solar flare in 1989.

There are, of course, more expensive ways to stabilize the grid, but Gentilly-2 does so by producing a useful product – cheap and reliable electricity.

Refurbishment of Gentilly-2 will provide another 30 years of clean emission-free cheap and reliable electricity. The lessons learned from the refurbishments of Point Lepreau and Bruce Power will ensure that there will be no significant schedule delay or cost over-run, as demonstrated by the successful refurbishment of Wolsong. It will also provide long-term employment in the region, helping the local economy, and will pave the way for future nuclear expansion to allow Quebecers to continue to enjoy security of supply and the lowest electricity rates in Canada.

In This Issue

In the last issue I mistakenly referred to our President as "Dr. John Roberts". As he pointed out to me, it is simply John Roberts – sorry John! Be sure to read his message in the CNS News section, which promises to be a regular feature for our Bulletin.

In this issue we have a report on the Nuclear Education and Outreach Workshop and Nick Sion reports on recent radiation protection events. There is also a feature on development of a spent fuel retrieval and safe storage system built by Rolls Royce for AECL.

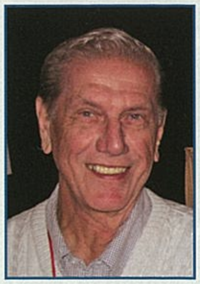
In CNS News we report on Richard Osborne, founder of the Canadian Radiation Protection Association, and recipient of the prestigious Sievert award. AECL hosted an Open House at Chalk River, which was a success due in part to the dedicated members of the CNS Chalk River Branch.

There are a number of items in General News, including resolution of the labour dispute at Candu Energy. In Endpoint, Jeremy Whitlock seamlessly mixes past and future.

I hope everyone had a safe and enjoyable summer. As for the upcoming seasons, climatologists warn not to expect the tropical weather we enjoyed last winter! Time will tell.

Your comments and letters are always welcome!

From The Publisher



The Society

On the surface this summer has been a quiet time for the CNS. The only event was the **Nuclear Education and Communication Workshop** held at the end of August. However, behind the scene there has been much activity in the Council of the Society and within the organizing committees for the three events being held this fall.

The Council wrestled with the budget for 2013 since an initial prediction was for a substantial deficit. However, after close examination of almost all programs and activities, that predicted deficit has been almost eliminated.

Organizers of the meetings this fall have completed all their planning and are preparing for the actual events. The first one is the **24th Nuclear Simulation Symposium** being held in Ottawa, October 14-16. This is a gathering of specialists where even the titles of some of the papers are unintelligible to those outside of that discipline. However, their work is essential for analysing both normal functioning of various systems and the likely consequences of failures.

It will be followed a few weeks later by the **2nd International Meeting on Small Reactors**, on November 7-9. It is also being held in Ottawa. There has been a growing interest in small power reactors in many countries over the past few years. And Jeremy Whitlock, in his Endpoint in this issue, postulates some of the potential of using small nuclear power plants in the Canadian Artic.

AECL did develop a very small reactor, SLOWPOKE, some fifty years ago. There are five operating in Canadian universities. It operates in the kilowatt range and was designed primarily for teaching purposes. That design is so inherently safe that the regulator allows it to operate without an attendant. Then, starting in the 1980s, AECL developed the MAPLE design, which was used for the successful Korean HANARO research reactor. Despite the termination of the isotope reactors here, that concept has much promise.

Then, just a week later, November 11-14, there will the large **7th Steam Generators to Controls Conference**, being held again in the Toronto Convention Centre. This conference is aimed at the operators of our nuclear power plants as a venue where they can exchange their experience. The subject matter is so broad, covering almost all systems of large nuclear power plants, the organizers felt compelled to use the cryptic title chosen.

There is still time to register for any of these events. Just contact the CNS office.

Communication

The NEO Workshop, mentioned at the beginning, dealt with possibly the greatest barrier to the wider use of nuclear science and technology, the misperceptions widely held by the public.

Some of the apprehension of the public to things nuclear undoubtedly comes from its introduction – the atomic bombs. The early nuclear program was associated with the military which operated secretly. This disturbed many and led some to suspect what little information was revealed. A sizable group developed a disbelief which can be observed in the statements from the militant antinuclear groups. The openness of the current civilian nuclear programs has yet to quell their very vocal criticism.

However, the nuclear community has itself to blame for much of the misperceptions. Probably the most serious is the misuse of the LNT – linear no threshold – hypothesis of radiation effect. Originally proposed as a guide to controlling radiation exposure of workers it began to be used, even by many in or associated with the nuclear community, to predict the likelihood of cancer deaths when a large population is exposed to very small radiation doses. An example is the recent report on radon in houses, the subject of a letter in this issue from Jerry Cuttler, where Health Canada stated, in its media release, the number of cancer deaths that would result despite the lack of reference to actual death rates.

There are other examples of the nuclear community leaving conflicting implications of potential harm. During the 1980s and 1990s, we spent hundreds of millions of dollars developing elaborate methods of encasing and burying spent nuclear fuel while at the same time telling the public there was no problem.

As well as clarifying our message, the method of communication must be considered. A decade or so ago the Canadian Nuclear Association ran an extensive (and expensive) campaign in the print and television medias. Polls showed it was effective. Now, as pointed out by Laura Allardyce at the NEO Workshop, CNA is focussing on what is called the social media. Whether or not that approach is adequate, remains to be seen.

Until the nuclear community, as a whole, speaks with a consistent but open and honest, manner, the sceptics and antinuclear groups will continue to unduly influence the public.

Fred Boyd

Contents

Editorial 1

Third NEO Workshop Explores Communication Challenges 5

Report on IRPA13 9

Legacy Program Acquires Special Equipment for CRL Spent Fuel 13

Letters to the Editor 17

Nuclear Power Plant Accident Handbook 21

Spent Fuel Response after a Postulated Loss of Spent Fuel Bay Cooling Accident 26

EC6 Safety Enhancement – Including Impact of Fukushima Lessons Learned . . . 34

General News

Labout dispute at Candu Energy ends . . 42

AECL holds public Open House for first time in over a decade 43

CNSC invites comment on Safety Culture 43

Point Lepreau approved to increase power 44

CNS News

Message from the President 46

Richard Osborne receives Sievert Award 46

Look to the Stars, What an Exciting CNS Event! 47

News from Branches 48

Obituary 50

Calendar 54

Endpoint 55

~ Cover Photo ~

Artificial Bank Swallow nesting habitat at Darlington. (See page 11 for story)

Photo courtesy of Ontario Power Generation

CANADIAN NUCLEAR SOCIETY
bulletin
DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

ISSN 0714-7074

The *Bulletin of the Canadian Nuclear Society* is published four times a year by:
The Canadian Nuclear Society
655 Bay Street, 17th Floor
Toronto, Ontario, Canada, M5G 2K4
Telephone (416) 977-7620
Fax (416) 977-8131
e-mail: cns-snc@on.aibn.com

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

CNS provides Canadians interested in nuclear energy with a forum for technical discussion.
For membership information, contact the CNS office, a member of the Council, or local branch executive.
Membership fee 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.

Editor / Rédacteur
Ric Fluke Tel. (416) 592-4110
e-mail: richard.fluke@amec.com

Publisher
Fred Boyd Tel./Fax (613) 592-2256
e-mail: fboyd@sympatico.ca

The comments and opinions in the CNS Bulletin are those of the authors or of the editor and not necessarily those of the Canadian Nuclear Society. Unsigned articles can be attributed to the editor.

Printed by The Vincent Press Ltd., Peterborough, ON

Canada Post Publication Agreement #1722751

Candu's EC6 achieves important design review milestone from CNSC.

Candu proudly announces that the Enhanced CANDU 6® (EC6) reactor has achieved Phase 2 pre-project design approval from the Canadian Nuclear Safety Commission. With the completion of this review, the 700MW class natural uranium EC6 has achieved an important milestone – meeting Canadian regulatory requirements for licensing.

This landmark step builds on the evolution and leadership of Candu innovation and safety in the global marketplace.

Candu Energy Inc. brings a new vision to Canada's role in nuclear energy and is dedicated to developing and maintaining a worldwide supply of safe, economical and reliable nuclear power.

Candu EC6®

Powering prosperity.

www.candu.com

Third NEO Workshop Explores Communication Challenges

by FRED BOYD

The third *CNS Workshop on Nuclear Education and Outreach* took a broader look at the challenges in effectively communicating the positive aspect of nuclear technology than the two previous ones. Coming from both inside and outside the nuclear community the presenters focussed on different aspects of the communication task.

Organized by the Education and Communication Committee of the Canadian Nuclear Society with the generous support of a number of companies and organizations, the Workshop was held in the Sheraton Hotel, Hamilton, Ontario, on August 27 and 28, 2012, with 40 participants.

Following a modest reception on the Sunday evening, the Workshop attendees were welcomed on the Monday morning by **Brad Moore**, the chair of the organizing committee, and **John Roberts**, current president of the CNS,

Jason Donev, an active CNS member from the University of Calgary, set the stage for the Workshop by expressing his wish that the public can be convinced to want nuclear as it appears to want wind and solar. He referred to the recent book, *Science of Fear*, in which author Dan Gardner emphasized the conflict between what we think with our head and what we feel with our "gut". The media wants stories, Donev stated. Noting a recent tragedy in Alberta when several teen-aged boys were killed by a train hauling coal, he said that could have provided an opportunity to note that it takes 100 trains of 100 cars each year to feed a coal-fired plant producing the same power as a large nuclear unit.

In his summary he proposed three objectives for communication about nuclear energy: (1) define our common goal; (2) study the science of fear; (3) define the actions we should take.

The first formal presenter was **John Peevers**, Manager of Investor and Media Relations at Bruce Power. After acknowledging that he was relatively new to the nuclear field, he stated that from his long experience in the news field he proposed three objectives for those involved in nuclear communications: use simple language; accentuate the positive; be well prepared.

He noted that the visitors' centre at the Bruce site had been extensively upgraded and they have received many compliments. In closing, he noted that, when things go wrong we have just one chance to explain and reassure the public.

Next was **Shelley Rolland-Poruks**, of Atomic Energy of Canada Limited, who stated that her focus is on the communities surrounding the Chalk River Laboratories. As the second largest employer (after the Petawawa military base) the local population is very interested in the activities of CRL.

She acknowledged that AECL had been in somewhat of a crisis communication mode over the past few years, noting the NRU isotope crisis of 2007, the leak and shutdown of the reactor in 2009 and then the Fukushima tragedy of 2011. The restructuring of AECL in 2011 added to the communication challenge. But, she noted, an Open House, held at the laboratory just two weeks previously, drew well over 2,000 visitors.

The third speaker of the first morning was **Ted Gruetzner**, of Ontario Power Generation. He began by referring back to the Fukushima event and noted that had led some within the electricity field to advocate for smaller, safer nuclear power plants. There are, he commented, many within the electricity community who are against nuclear. Fukushima led to a "media storm", he stated, and observed that the "ethnic" press was particularly anti-nuclear.

Turning to OPG, he noted that the environmental approval for the proposed new plants at the Darlington site. Inclosing he observed that in Ontario more people are concerned about the cost of nuclear than about safety.

The three presenters then sat as a panel for an open discussion with the audience. A variety of topics were raised. On the question of security of supply Gruetzner commented that the provincial government has avoided that issue. He, and the other panelists, agreed that the nuclear industry needed more credible and personable spokespersons.

Following lunch **Josh Rosenau**, from the National Center for Science Education in the USA, began the afternoon session by first outlining the objective of that organization. Among other goals they aspire to bring a "human perspective" to science and its applications. There is a broad culture of science denial among the general public in the USA, he commented, despite the many aspects of our modern life that derive from science. But, he contended, science denial is not irrational. Those holding that view have beliefs which are internally consistent.

He noted the apparent inconsistency of public opinion polls that showed 69 per cent of the public accepting nuclear for electricity production while other polls reported that 70 per cent believed nuclear was dangerous. His organization is trying to shift the science debate to convince the public that science is human and science is social.

The next speaker, **Jo-Ann Facella**, of the Nuclear Waste Management Organization (NWMO), began by providing a short history of the nuclear waste debate, starting with the Porter Commission hearings in 1978, the extensive nuclear waste research program of the 1980s, the Seaborn Panel of the late 1990s and the eventual passing of the Nuclear Waste Management Act and creation of NWMO in 2002.

NWMO is mandated to "work collaboratively with Canadians" to develop a "socially acceptable" method of dealing with the radioactive spent fuel from Canadian nuclear reactors. Much of NWMO's effort over the first few years of its existence was involved in holding a large number of town-hall meetings and discussion groups to determine the attitude of Canadians. By 2007 it had developed a program titled "Adaptive Phased Management" which was accepted by the federal government. Now, the organization is in extended conversations with a number of communities, mostly in Ontario and Saskatchewan, regarding the siting of a deep geological storage repository.

To a question about possible opposition to the transporting of the spent fuel to the chosen site, she observed that was well into the future and hoped that by then the many communities that have considered hosting the repository would help convince others of the safety of the operation.

The final speaker of the day was **Bob Oliver**, who, as Executive Director of Pollution Probe, was a surprise to the older members of his audience because in its early days that organization was anti-nuclear. However, he dispelled that bias by stating the major focus of Pollution Probe is now "energy literacy" among the population at large. His organization is currently developing a business case to raise funds for the creation of a Centre of Energy Learning. The concept is to be "energy neutral" but to develop citizen-based understanding of energy. By delving into the components of an energy system it is possible to identify attributes that lead to value, he stated. This could lead to an on-going dialogue with no pre-set positions. Although they are still working on their business case he stated that there is early information on the Pollution Probe website.

To a question, he commented that our federal system is a hindrance in energy policy since most of the responsibility for energy matters is assigned to the provinces. That, he stated, has impeded the development of inter-provincial connections, such as for electricity, which would be beneficial to the country as a whole.

That evening there was a very pleasant reception and dinner with no speaker or program. The result was that many stayed long after the meal in animated discussions.

The next morning had just two speakers.

First was **Laura Allardyce**, from the Canadian Nuclear Association, whose focus was on "social media": The objective, she said, is to develop conversation. Each of the prominent media: Twitter; Facebook; You Tube; etc., have different audiences, she noted. CNA is using: on-line newspapers and blogs; Facebook; Twitter and mobile apps. She gave the following statistics for the different media: Twitter 61%; News 24%; Blogs 6%.

CNA has an online program Talking Nuclear to enable a dialogue on the Canadian nuclear program. She said she spends much of her time in actual "conversations". The content is different for each person or group. She commented that for difficult questions she might engage others to assist. Quoting Wayne Robbins, of Ontario Power Generation, she stated that "the greatest risk of social media is to ignore it".

The final presentation was by **Denise Chartrand**, a doctoral candidate at Royal Roads University, who is exploring methods of how to achieve people and organizations working together to achieve sustainable resource development. She is focussing on how the many groups involved or interested in resource development or similar problems can develop true dialogue. She mentioned that her perception is that most people are afraid of nuclear energy. There is a pressing need, she suggested, for the nuclear community to be more transparent.

A major challenge, she said, is dealing with conflict when those involved perceive they have incompatible views or feelings. Conflict can lead to tension, fear and other negative reactions, she commented. But it can also be perceived as natural and leading to innovative ideas. She noted typical problems in group discussion such as using technical language or talking TO someone rather than having a conversation. For an effective group discussion she said ground rules need to be established, including; process; timing; agenda; conflict management; goal(s).

For the balance of the morning and the first part of the afternoon the attendees were divided into groups for table discussions organized by **Dave Shoesmith**, from Western University.

In mid-afternoon, most of the attendees arranged various ways to go to McMaster University for a tour of the McMaster reactor and associated laboratories.

The Workshop was made feasible by the generous contributions of several sponsoring organizations; Ontario Power Generation; Organization of CANDU Industries; Canadian Nuclear Association; Kinectrics; Canadian Nuclear Society; Candu Energy Inc.; University Network of Excellence in Nuclear Engineering.

The Workshop organizing committee: L to R: Brad Moore; Jason Donev; Charlene Gillis; John Kraznai; Ben Rouben. Missing: Jeremy Whitlock.

Attentive Workshop participants listen to a presentation.

First panel: L to R: Shelley Rolland-Poruks; John Peevers; Ted Gruetzner.

Report on IRPA13

By NICHOLAS SION

[Ed. Note: This article has been edited for length. A full version is available from the author.]

2012 is the year when Glasgow Scotland hosted IRPA13, the every four year event of the International Radiation Protection Association. Some 1500 delegates from 77 countries made 350 oral presentations in 65 sessions, and presented 1400 Abstracts. There were 150 Exhibitors from worldwide including a group of 30 Canadians. IRPA13 was held 13-18 May, 2012.

The venue was at the Scottish Exhibition Conference Centre (SECC) with the main sessions held at the Clyde auditorium affectionately labeled by the locals as the "armadillo" (see photo). Social media - Twitter and email - was used to submit questions for many technical sessions for the question and answer process. Podcasts and live webcasts were also used. IRPA is the voice of Radiation Protection who at this Congress garnered the world's largest collection of radiation specialists.

Dr. Osborne receiving Sievert Award from Dr. Kase, President of IRPA.

The Sievert keynote speaker was Dr. Richard Osborne, founder of the Canadian Radiation Protection Association (CRPA), a mentor to many including myself, and a legend in tritium technology. His talk was titled "The Story of Tritium".

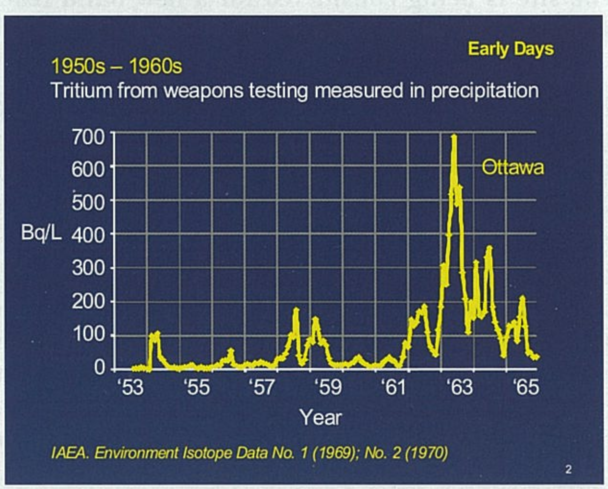


Fig.1: Peak of Atmospheric Tritium Levels in 1963 in Ottawa Region.

Dr. Osborne was presented the Sievert Award from Dr. Kase, president of the IRPA. *(See separate report in CNS News)*

Cheri Hall, PhD Student at UOIT.

Other Canadian contributors were Cheri Hall of UOIT (University of Ontario Institute of Technology) with her Poster presentation on "Characterizing Canine Dose from Computed Tomography Imaging". It deals with the growing concern of the effects from low dose imaging in Computed Tomography or CT scans. Cheri advocates more research to link stochastic effects at low doses of radiation. This is one of many cases to justify a review of the LNT dictum.

Nicholas Sion by his Poster.

Nicholas Sion presented both a Poster and a full paper titled "Hazards and Countermeasures on Extended Space Missions". It lists the known hazards that will be encountered by astronauts when on extended interplanetary missions to planets or to an asteroid. The radiological hazard is ionizing galactic radiation which, on Mars is 167-375 times higher than on earth. This hazard exceeds the dose exposure limits set by NASA.

James Cleary of UOIT.

James Cleary and Professor Edward Waller, both of UOIT, presented a Poster titled "Contact Dose Rates from Encapsulated Sources". Sealed sources emit significant amounts of secondary electron radiation that needs quantification for accurate contact dose estimation. The relative contributions of these secondary electrons were modeled and were found to be in good agreement with published values for ^{137}Cs, ^{60}Co, ^{192}Ir and ^{226}Ra. However, the objective of this study was to generate revised contact dose rates from Monte Carlo modeling software and com-

Ed Waller, Prof at UOIT.

pare this to results published in NCRP Report No. 40 that are 3-4 times higher. The implication is that dose calculations based on NCRP40 values will overestimate dose and lead to underestimated risk when compared to biological indicators.

Another space oriented paper was presented by NASA on OLTARIS (On-Line Tool for Assessment of Radiation in Space), titled "Comparison of Carrington Class SPE Radiation Exposure Estimates on Mars Utilizing the CAM, CAF, MAX and FAX Human Body Models". (The Carrington Effect is the largest solar storm on record that occurred in 1859. Its aurora was observed even in the Caribbean, and with its brightness one could read a book at night.) It estimates the radiation dose in an aluminum shielded habitat on Mars and how they compare to NASA's Permissible Exposure Limits (PELs). The results of this study showed that the light CO_2 Martian atmosphere offered additional shielding and will not exceed the PELs when located in a permanent habitat, but will not withstand a Carrington class solar storm.

Fukushima Dai-Ichi – Lessons Learned

There were two Sessions on the Fukushima Dai-Ichi incident and a full Plenary where many high caliber speakers from the IAEA plus their Japanese counterparts who made presentations detailing the incident itself, the aftermath, and the lessons learned. Known locally as the Tohoku earthquake, it was preceded by a number of large foreshocks beginning with a 7.2 Mw (Moment Magnitude) quake on 9 March 2011 followed by 3 more quakes of 6 Mw the same day. More than 1000 seismometers relayed the message to the Earthquake Early Warning System that sent out warnings of an impending earthquake and this is believed to have saved many lives. (Source: Japan Quake Facts)

The critique was that hasty decisions were immediately made followed by some contradictory ones leaving the public somewhat confused. The lack of information on radiation effects led to statements by the public, such as "school girls are not able to have a baby in the future"; "I was told to terminate my pregnancy". Both are invalid statements compounded by the fact that the public associates radiation with severe effects, cancer and death.

There was a lot of confusion over terminologies, such as equivalent dose and effective dose which share the same unit of Sievert, and why a dose greater than 1 mSv/y was unacceptable before the accident while afterwards doses of 20 to 100 mSv/y are considered acceptable.

The Business Side of IRPA

- IRPA14 (2016) will be held in Cape Town South Africa.
- South Korea was given the go-ahead to plan to host IRPA15 (2020) in Seoul. In default, Australia would be the host in Adelaide. Brazil's proposal for Rio de Janeiro came in third.

Dr. Gary Kramer with his award.

Dr. Gary Kramer, the Canadian representative on IRPA's Council was honored with an award for his diligent services rendered to IRPA over two terms (8 years).

Site visits were organized to Sellafield and to the nuclear submarine base at Faslane. See accompanying report

Technical site visits of IRPA13/Glasgow

By NICHOLAS SION

Among the site visits organized were to Sellafield and to the nuclear submarine base at Faslane.

Site visit to Sellafield:

Sellafield began its nuclear operations in the early 1950's to focus on a weapons program, nuclear generation, storage and chemical separation of nuclear fuel. The resulting legacy of a hurried program are facilities needing the largest and most complex nuclear cleanup work in the world, with 170 major nuclear facilities and 2200 other buildings housing activities that cover the entire nuclear fuel cycle. The site has become the most innovative and complex nuclear decommissioning project in the world.

The Sellafield nuclear reprocessing plant now covers the Windscale and Calder Hall nuclear reactors both of which are being decommissioned and dismantled and are now owned by Nuclear Decommissioning Authority.(NDA). Subsequently NDA contracted its staff to a consortium comprising AREVA, AMEC, and URS in 2008. The main activity is decommissioning and making MOX fuel at THORP (Thermal Oxide Reprocessing Plant) for power reactor fuel.

The site is being considered for a new build reactor to be completed before 2025.

Site visit to HM Naval Base Clyde at Gare Loch

The second site visit was to the nuclear submarine base at Faslane operated by some 6500 civilians and service personnel. This is an operational base for nuclear submarines and their associated nuclear weaponry for patrol and operational missions. It is part of the NATO deterrence strategy. The key role of this base is to support the Royal Navy in maintaining Continuous At Sea Deterrence by ensuring that at least one Vanguard Class submarine is on patrol at sea every day of every year. It is the home base for the Astute, the Vanguard, and the Trafalgar types of nuclear submarines. The Astute class is a hunter type of submarine and is the most capable. It is fitted with the latest of equipment, has no periscope and its navigation system is classified.

Faslane is also the base for submarine rescue missions. After the Russian Kursk submarine incident (12 August 2000) the need to respond globally to peacetime submarine disasters by international coordination was underlined and the International Submarine Escape and Rescue Liaison Office (ISMERLO) was established in 2003 in Norfolk, Virginia

In a typical rescue mission, the ROV (Remote Operating Vehicle) is sent down first to ascertain the layout of the damaged sub and for signs of life. The rescue sub then goes down and aligns itself above the universally sized escape hatch on the damaged submarine, up to an angle of 33 degrees. When the 2 pilots and a rescue officer (i.e. a crew of 3) on board are assured there is no leakage and the rescue sub is pressurized to that depth, the hatches are opened and the transfer of people begins up to 9 or 13 (the capacity of the rescue sub). Upon re-surfacing the rescued submariners are placed into a hyperbaric chamber of 36 person capacity till they are depressurized to normal pressure. This can take days. The maximum depth to which this equipment can operate is 600-700m below which depth rescue cannot be attempted.

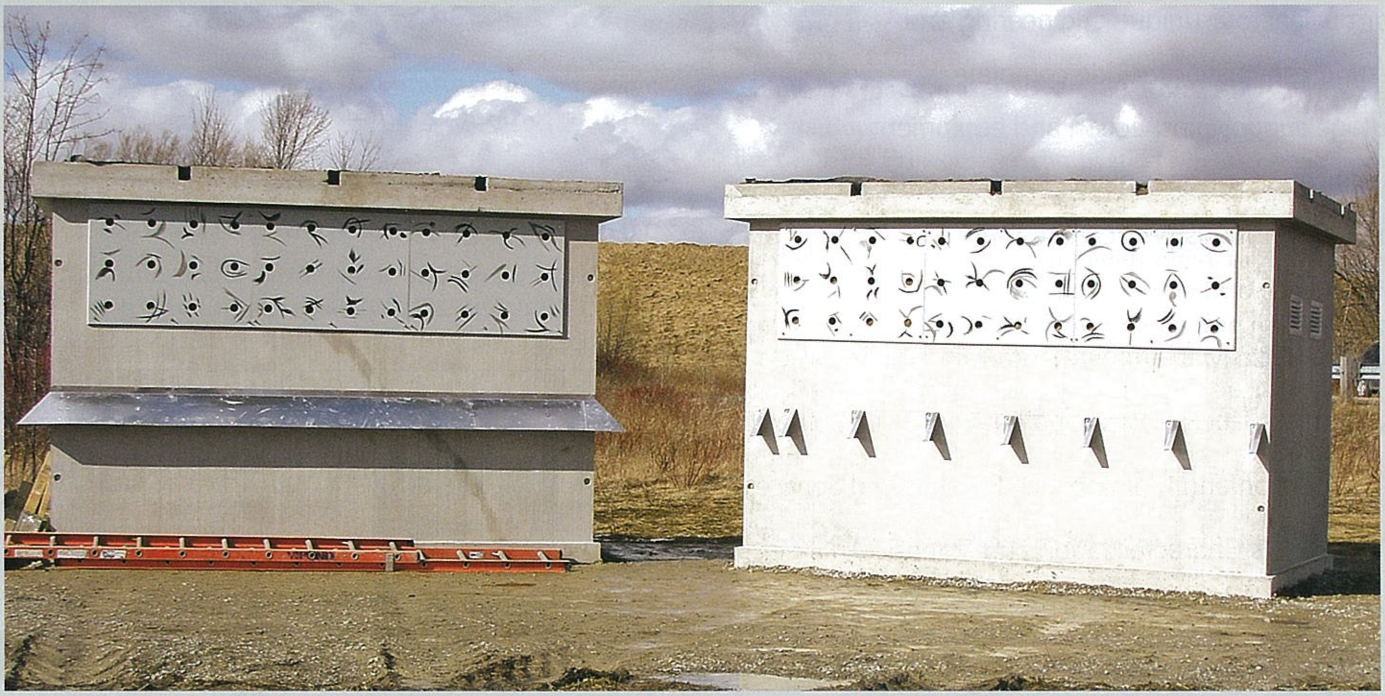
Naval base at Faslane, 2 miles long but of narrow width.

Artificial Bank Swallow Nesting Habitat

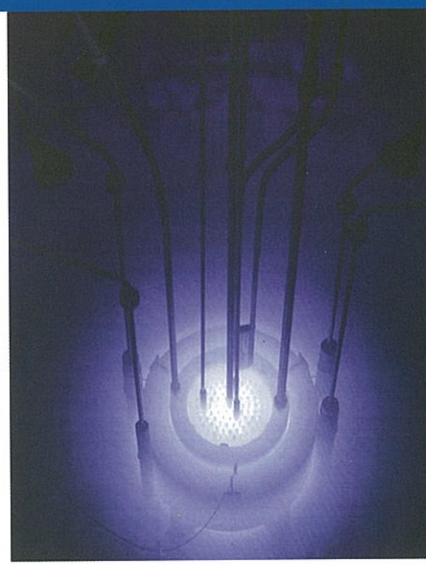
Shown below and on the Cover Page is a newly constructed artificial Bank Swallow nesting habitat located near the site of Darlington New Nuclear (photos courtesy of Ontario Power Generation). A monitoring program, involving Bank Swallow colony and burrow counts, was established in 2008 and continues annually.

OPG has constructed this pilot artificial Bank Swallow nesting habitat that is available for the Bank Swallows upon their return migration this year.

OPG has also entered into an agreement with Bird Studies Canada to support Bank Swallow studies on Lake Erie, which has one of the species' largest breeding concentrations in the world, to help increase the understanding of this species. This work began in 2010 and will continue throughout 2012.



GENERATING SUCCESS—FOR 100 YEARS



Kinectrics is celebrating 100 years of success in providing advanced technical expertise to the electricity generation industry.

For nuclear, our unique engineering and testing capabilities include complete outage support, inspection and equipment qualification, nuclear plant chemistry and many other industry-accredited services.

- Life Cycle Management and Plant Life Extension
- Genuine Nuclear Parts and Equipment Qualification
- Inspection and Maintenance Systems and Services
- Materials Characterization and Forensic Analysis
- Plant Chemistry and Nuclear Waste Management
- Regulatory Affairs and Licensing

KINECTRICS

KINECTRICS★US

candesco
Part of the Kinectrics Group

AXIOM
NDT CORPORATION
A Kinectrics Company

kinectrics.com kinectrics.us axiomndt.com candesco.com

Legacy program acquires special equipment for CRL spent fuel

Canadian arm of Rolls Royce delivers unique machines

by FRED BOYD

Background

Six years ago the federal government accepted its responsibility for the radioactive waste that has resulted from the six decades of nuclear research and development conducted by Atomic Energy of Canada Limited and its predecessor operator of the Chalk River Laboratories (CRL) the National Research Council (1944 - 1952).

Nuclear research and development and, particularly, reactor operation at CRL has resulted in outdated and unused research facilities and buildings and a wide variety of buried and stored radioactive waste.

In 2006 the federal government established the *Nuclear Legacy Liabilities Program (NLLP)* with an initial funding of $520 million. The mandate of the NLLP is to deal with the radioactive waste arising from the nuclear research and development program of AECL and also prototype reactors in which it was involved. The timeline for the NLLP extends several decades into the future.

The NLLP is implemented through a partnership of Natural Resources Canada (NRCan) and AECL. NRCan is responsible for policy direction and oversight, while AECL is responsible for program implementation and all licences, facilities and lands.

About 70 percent of the liabilities from AECL activities are at CRL. Other sites that will be restored under the NLLP are: the Whiteshell Laboratories and Underground Research Laboratory in Manitoba; NPD and Douglas Point reactors in Ontario; and the Gentilly 1 reactor in Quebec.

Fuel Packaging and Storage Project

At CRL, the major problem is the spent fuel from the research reactors (primarily NRX and NRU). This is currently stored in tile holes (vertical, cylindrical, below ground, storage structures). The most recent tile holes are effective and safe but some of the oldest ones have become flooded from surface water leakage, resulting in some fuel corrosion.

The Fuel Packaging and Storage Project (FPS) involves the design, licensing, construction and commissioning of a facility to dry, re-package and safely store the waste from about 100 of the 3,000 tile holes at the Chalk River Laboratories. The new CRL above ground storage facility will have a controlled and monitored environment to prevent further corrosion of the fuel, which will remain there until a national deep geologic repository is established.

Neil Alexander, General Manager of Rolls Royce Civil Nuclear Ltd. (L) symbolically turns over the components of a Fuel Retrieval and Transfer system to Bob Walker, president of AECL at a ceremony in Peterborough, Ontario, May 2012.

To develop and build the specialized equipment needed to remove the corroded fuel and place it in a new storage facility, AECL chose **Rolls Royce Civil Nuclear Ltd.**, located in Peterborough, Ontario, which is a part of the UK based Rolls Royce empire.

Rolls-Royce designed and built the major sub-systems for the FPS Project over the past five years. A ceremony was held at its Peterborough plant last May when Neil Alexander, General Manager of Rolls Royce Civil Nuclear, symbolically turned over the equipment to AECL president, Robert Walker. The actual shipment to Chalk River took place in August 2012. Commissioning of the several components will take place over the fall of 2012 and the actual transfer of the damaged fuel will begin in 2013.

The package supplied by Rolls Royce includes many components:

a) Fuel Retrieval and Transfer System

This complex machine will orient a shielded Retrieval Flask over a target tile hole and move a historic storage container from a tile hole into the Retrieval Flask. The retrieval system is remotely operated. A moveable collar provides radiation shielding between the flask and the tile hole. A Transfer Vehicle moves the loaded

Retrieval Flask from the tile array to the processing facility, where the Retrieval Flask lowers the historic container into the drying system.

b) Packaging Station

This shielded device orients the Retrieval Flask and directs the historic fuel into a new container in the drying system. A storage cap is removed and inserted by a shielded Capping Tool. A thin gauge, disposable liner directs any residue into the new container.

c) Fuel Packaging System

This system inserts a new shielded storage container into the drying system prior to the loading of the historic fuel. The system removes the containerized dried fuel and places it in a new, indoor storage array.

d) Vacuum Drying System

This system uses a low-temperature vacuum process to remove moisture from the retrieved fuel. The system operates automatically, cycling until the moisture has reached an acceptable minimum value.

e) Storage Containers

These containers receive and retain the historic fuel. A vented closure cap prevents the container from pressurizing during the vacuum drying process.

f) Storage Tubes

These tubes receive the Storage Containers, providing a means of containing an inert gas atmosphere around the Storage Containers. Shield Plugs with gas tight plates seal the Storage Tubes.

Members of the staffs of Rolls Royce and its principle suppliers pose in front of the Fuel Retrieval and Transfer machine during the hand-over ceremony held in May 2012.

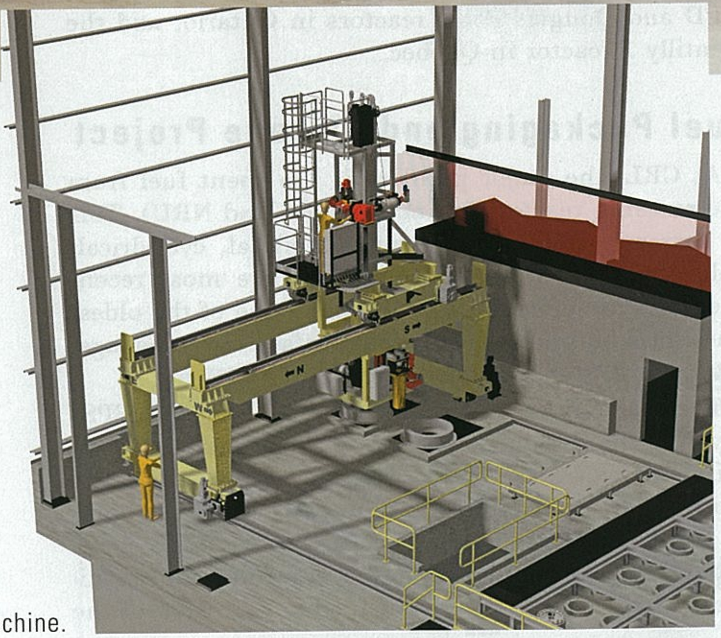


Fig. 1: A model of the Fuel Retrieval machine.

Another Bogus Radiation Scare – Radon in Homes

by JERRY CUTTLER

Dear Editor

I am upset after reading the recent news reports about Health Canada's "research" that radon in homes is causing unnecessary lung cancer deaths. Our public servants have carried out a cross-Canada survey of radon concentrations in homes (Health Canada 2012). The aims of their study were to obtain an estimate of the proportion of the Canadian population living in homes with radon gas levels above the guideline of 200 Bq/m³ to identify new areas of this health risk. Their results indicate that 6.9% of Canadians are in such homes (similar to their 1970 results). The areas with high levels of indoor radon are more prevalent in Manitoba, New Brunswick, Saskatchewan and the Yukon. Nunavut and PEI had the lowest levels. The authors state that their results can be used by governments and health professionals to help prioritize radon outreach and education efforts, and testing and remediation. Their next step is to correlate radon level and home characteristics, and also develop radon mapping methods. Several sentences in the introduction link radon with lung cancer, based on early studies of uranium miners and later studies in homes. "It is estimated that about 10% of all lung cancers worldwide are related to radon exposure."

Based on interviews with Health Canada, the CBC (2012) reported 1) hundreds more cases annually than in the late 1970s, 2) radon is a very serious risk, 3) 3,261 radon-induced lung cancer deaths expected each year, of which 927 could be prevented by installing ventilators . The National Post (2012) reported 1) that radon causes 16% of the lung cancer cases, up from the 10% estimate accepted for decades, and 2) that Canadian Cancer Society acknowledges these "important findings."

Table 2.3 of Canadian cancer statistics (CCS 2012) shows no hint of special lung cancer incidence in "the high radon provinces." The rates for males in BC, AB, SK, MB and ON are: 49, 52, 55, 58 and 53 cases per 100,000 respectively. The rates in QC, NB, NS, PE and NL are: 83, 78, 73, 74 and 68 cases per 100,000. For females, the rates from BC to ON are: 42, 46, 52, 45 and 43 cases per 100,000, while the rates in QC to NL are: 60, 59, 57, 51 and 49 cases per 100,000.

Health Canada likely used the linear no-threshold (LNT) theory to estimate the number of cases, even though an ecological study (Cohen 1995) tested and disproved the LNT theory for calculating excess lung cancer mortality based on radon level in homes. B. L. Cohen corrected his results (Figure 1) for smoking and other confounding factors. Many other studies have been carried out on human lung cancer risk from radon, including case-controlled studies. A review of these studies (Leonard et al. 2012) concluded that the assumption of linearity of risk by the LNT model is invalid.

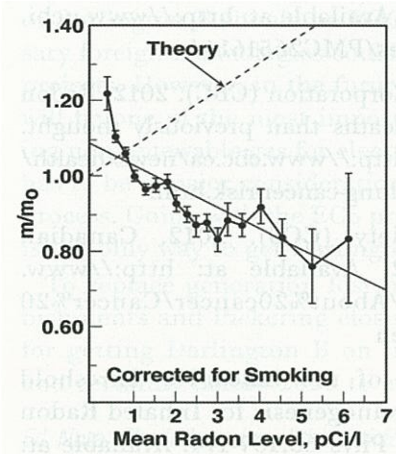


Figure 1: Ecological test disproves the LNT theory of radiation carcinogenesis (Cohen 1995).

Radiation and Health (Henriksen et al. 2012), Chapter 7, pp 91-102, explains the sources of radon, how it is measured, how it enters homes, UNSCEAR 2000 indoor radon values (up to 50,000 and 85,000 Bq/m³ in Norway and Sweden), radon and lung cancer, epidemiological studies and radon regulations.

Inhalation of radon has been associated with positive health effects for many years (Becker 2003). Radon dissolves in the blood and circulates everywhere. It has been shown to provide relief from many types of inflammations. However, the many government-funded protection organizations ignore the beneficial effects of low doses. EPA practice (EPA 2004) states in Section 4.1.3, Page 53: "...as the purpose of a risk assessment is to identify risk (harm, adverse effect, etc.), effects that appear to be adaptive, non-adverse, or beneficial may not be mentioned." This is strongly biased, unacceptable to science and a disservice to society.

My personal experience in a spa in Boulder, Montana, breathing air containing 1650 pCi/L (61,000 Bq/m³) of radon for 30 hours and drinking many glasses of radon-saturated water, was the complete relief from a very painful tooth/jaw infection. Several weeks later, a special dental surgeon removed the damaged tissue and replaced it with bone matrix material.

Measuring radon in the basement and installing forced ventilation, if the level exceeds 200 Bq/m³ (5.4 pCi/L), will cost several thousand dollars. The stigmatized house will be difficult to sell (significant devaluation). And the reduced radon level could ***increase*** lung cancer mortality (see Figure 1).

References:

Becker K. 2003. Health Effects of High Radon Environments in Central Europe: Another Test for the LNT Hypothesis? Nonlinearity in Biology, Toxicology, and Medicine 1(1):3-35. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2651614/

Canadian Broadcasting Corporation (CBC). 2012. Radon linked to more cancer deaths than previously thought. August 17. Available at: http://www.cbc.ca/news/health/story/2012/08/17/radon-lung-cancer-risk.html

Canadian Cancer Society (CCS). 2012. Canadian Cancer Statistics 2012. Available at: http://www.cancer.ca/Canada-wide/About%20cancer/Cancer%20statistics.aspx?sc_lang=en

Cohen BL. 1995. Test of the Linear-No Threshold Theory of Radiation Carcinogenesis for Inhaled Radon Decay Products. Health Phys 68:157-174. Available at: http://www.phyast.pitt.edu/~blc/LNT-1995.PDF

Health Canada. 2012. Cross-Canada Survey of Radon Concentrations in Homes. Available at: http://www.hc-sc.gc.ca/ewh-semt/alt_formats/pdf/radiation/radon/survey-sondage-eng.pdf

Henriksen T and Biophysics Group. 2012. Radiation and Health. University of Oslo. Available at: http://www.mn.uio.no/fysikk/tjenester/kunnskap/straling/radiation-health-2012.pdf

Leonard BE, Thompson ET and Beecher GC. 2012. Human Lung Cancer Risks from Radon, Part I, II and III. Dose-Response 10:415-461. Available at: http://dose-response.metapress.com/media/12d237n82p6jwndc5jvw/contributions/j/2/3/7/j237117038483w7j.pdf

National Post. 2012. Radon gas deadlier than thought: Radioactive substance causes 16% of lung cancer cases, Health Canada says. August 17. Available at: http://news.nationalpost.com/2012/08/17/radon-gas-deadlier-than-thought-radioactive-substance-causes-16-of-lung-cancer-cases-health-canada-says/

US Environmental Protection Agency (EPA). 2004. An examination of EPA risk assessment principles and practices - a Staff Paper prepared for the US EPA by members of the Risk Assessment Task Force. EPA/100/B-04/001. Available at: http://www.epa.gov/osa/pdfs/ratf-final.pdf

Ontario's Darlington B must be on line before 2020 and must be CANDU

by DON JONES

By the end of 2012 after the restart of Bruce units 1 and 2 and with all eight units on line there could be up to 12,900 MW of nuclear generation being fed to the Ontario grid. Over the next 12 years or so units 3 and 4 at Bruce A, all four Bruce B units and all four Darlington units will be refurbished and Pickering A and B stations will be shut down for good. This will have significant impact on the Ontario grid.

Both Pickering stations are slated for shutdown in 2020 with a loss of 3,000 MW.

A World Nuclear Association report, "Nuclear Power in Canada", 2012 June 26, describes the Darlington refurbishment, "OPG plans to shut the reactors sequentially for 3.5 years each for refurbishment from 2016: unit 2 then, unit 1 in 2018, unit 3 in 2020 and unit 4 in 2021, so that no more than two are out of action at the same time." This means that from 2018 until half way through 2024, up to 1,760 MW to the grid from Darlington will be absent.

Bruce Power has said units 3 and 4 will be able to operate to 2020 after the present unit 4 outage work. The four Bruce B units started up in 1984/87 so based strictly on years in service they would likely need refurbishment before that date. So, by 2020 there could be two units at Bruce A/B being refurbished at the same time with the loss of around 1,600 MW. The exact number of Bruce units off line and their timelines will depend on the refurbishment schedule which has not yet been released.

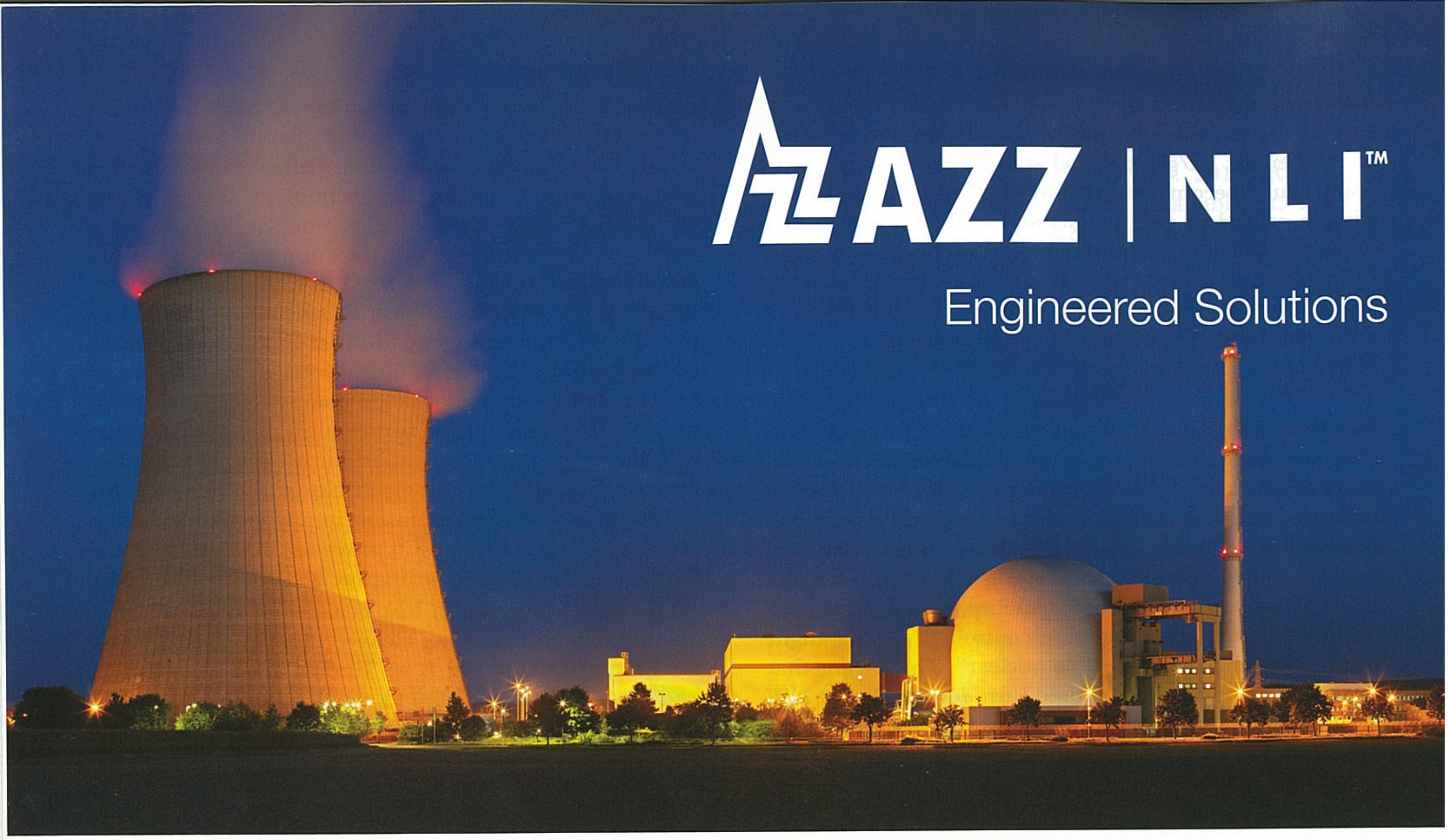
Altogether this will be a loss of about 6,400 MW of nuclear generation around 2020, half the nuclear generation capacity at the end of 2012. Assuming by 2020 up to 9,000 MW of hydro and around 9,000 MW of gas, excluding the rarely used 2,000 MW Lennox oil/gas-fired thermal station, gives total Ontario generation of about 24,500 MW, without wind/solar. This supply would also have to include an operating reserve and allow for forced and planned unit outages. Wind is unreliable so the Independent Electricity System Operator (IESO) assumes that only around 13 percent of wind will be available on the highest demand days. Reduced hydroelectric generation because of low precipitation has already resulted in an increase in coal and gas-fired generation and even use of the Lennox oil/gas thermal station. Low precipitation years could become more frequent due to changes in climate caused in part by gas and coal-fired generation. Replacing this loss in nuclear generation by gas will result in increases in greenhouse gas emissions and in generating costs much higher than nuclear. So far this summer there have been peak hourly market demands of 26,000 MW and Ontario demands of 24,000 MW.

The IESO now calls the output of Bruce B "flexible nuclear" based on the limited manoeuvring capability of the units using steam bypass without reactor power changes. CANDU fuel costs are very low and new CANDUs will make use of steam bypass and reactor power changes to manoeuvre electrical output down to zero if necessary and respond to five minute load-following dispatches from the IESO as well as having the capability to provide second to minute automatic generation control. The IESO might want to call this "ultra flexible nuclear". This means that 4,000 MW of new nuclear could turn down to 2,000 MW or less overnight if needed meaning that the grid could accommodate 14,000 MW of installed nuclear rather than the 12,000 MW of Ontario's Long-Term Energy Plan.

Canada's Enhanced CANDU 6 (EC6) is based on units that have been operating successfully for almost 30 years. The Canadian Nuclear Safety Commission would be able to approve this design much quicker than any competing foreign technology that it is not yet familiar with and which is not yet in operation, and Canadian companies in the supply chain are more familiar with CANDU than with foreign technology. Rather than delay Darlington B construction by studying different technologies, the first 2,000 MW or more of Darlington B should be EC6 units. If thought necessary foreign technologies could compete for subsequent projects. However, in the future ultra nuclear flexibility will be one of the most important attributes in replacing non-renewable gas for electricity generation and this has to be a major consideration in any vendor selection process. Going with the EC6 provides this flexibility and is the only way to get Darlington B online before 2020.

To replace generation lost because of nuclear refurbishments and Pickering closure there is a strong case for getting Darlington B on line as soon as possible, and certainly before 2020 to avoid power shortages.

Ed. Note: The full version of this article can be found at http://thedonjonesarticles.wordpress.com/2012/08/31/ontarios-darlington-b-must-be-on-line-before-2020-and-must-be-candu/



Everything Except Fuel.

Nuclear equipment: we provide it. This is not an overstatement. At NLI, we specialize in supplying our clients with the products they need. We are problem solvers. We do not simply react to plants' needs; we anticipate those needs and actively seek and develop new solutions before they become crises. Utilizing the finest partners, engineers, and technicians, our long list of products and services not only address current nuclear requirements, but will stay reliable and effective for years to come while increasing the bottom line. That defines our solid guarantee of service, standard-setting craftsmanship, and quality. **And that's why we're your single source.**

N NPT NS

www.azz.com/nli • 800.448.4124

Nuclear Power Plant Accident Handbook

A CNSC Emergency Operations Centre Tool

by C.J.P. COLE[1], T. NITHEANANDAN[2], M.J. BROWN[2], S.M. PETOUKHOV[2], A. WOOD[2]

[Ed. Note: The following paper was presented at the 33rd Annual Conference of the Canadian Nuclear Society, held in Saskatoon SK, 10-13 June 2012.]

Abstract

In response to the Fukushima Nuclear Emergency and the subsequent Emergency Operations Centre (EOC) response, the Canadian Nuclear Safety Commission (CNSC) Fukushima Task Force recommended that hardcopy and electronic version reference packages for all Canadian nuclear reactor sites are readily available to the Technical Support Team.

CNSC staff, in a cooperative agreement with Atomic Energy of Canada Limited at Chalk River Laboratories (AECL-CRL), has begun implementing this recommendation through the development of the Nuclear Power Plant (NPP) Accident Handbook. The NPP Accident Handbook will provide readily available reference material for technical staff involved in EOC operations. The NPP Accident Handbook will assist technical staff in finding site-specific and accident-specific details that will help them provide expert advice to the EOC team during a nuclear power plant accident.

1. Introduction

Recent experience by CNSC staff during exercises at the CNSC Headquarters Emergency Operations Centre (EOC) have highlighted the need for readily available information on plant layout, plant operations, accident scenarios and plant response, and anticipated operator actions and their consequences during nuclear accidents. In order to satisfy this need, CNSC staff has identified three independent, yet interlinked projects. The goal of the EOC Technical Support Team Project is to combine these three individual projects under one heading to ensure the EOC Technical Support Team has the required resources to function effectively and efficiently during EOC operations. As well, this umbrella project will reduce the risk of overlapping efforts by the project team members and ensure that all requirements of the Technical Support Team are met.

The three separate projects that will be combined under the "EOC Technical Support Team Project" are the:

1. EOC Technical Support Team Information Project;
2. NPP Accident Handbook; and
3. EOC Source Term Project.

2. CNSC Emergency Operations Centre

2.1 Role of the CNSC

The CNSC emergency organization must be activated for all events which are leading or could lead to significant on-site or off-site consequences, and where the consequences of the event will be strongly affected by the operator's actions [2].

During a nuclear emergency the CNSC's regulatory role is to provide assurance that appropriate actions are taken to limit the risk to health, safety, security and the environment. As such, the CNSC's emergency response objectives, as the federal regulator, are as follows [2]:

(a) Manage the CNSC emergency organization and response;

(b) Assess the safety significance of the emergency, where safety significance refers to the on-site impact, off-site impact and defence-in-depth degradation;

(c) Enforce relevant regulatory and license conditions to reduce the risk to health, safety, security and the environment;

(d) Provide appropriate technical advice and support, as requested or required;

(e) Coordinate and cooperate with licensee, provincial, federal and international response organizations; and

(f) Report to the public, the government and the CNSC organization on the CNSC response.

2.2 Role of the Technical Support Team

The Technical Support Team is a specialized group within the EOC and is comprised of technical specialists in the fields of fuel and physics, thermal hydraulics, containment systems, severe accident progression and mitigation, and radiation protection. The team is designated to meet the requirements of objectives (b) and (d) above. In order to effectively assess the safety

1 Canadian Nuclear Safety Commission, Ottawa, Ontario, Canada (christopher.cole@cnsc-ccsn.gc.ca)

2 Atomic Energy of Canada Limited, Chalk River, Ontario, Canada (nitheanandant@aecl.ca)

significance of the emergency, the Technical Support Team must be fully aware of the emergency scenario, be informed of the actions taken by the operators, and be able to assess the impact of such actions.

Requests for technical advice from on-site licensee staff or the off-site authority are directed to the On-Site and Off-Site CNSC Representatives. The Representative provides the advice or obtains it from the CNSC EOC. If required, the CNSC provides appropriate advice to other organizations (licensee, provincial, federal or international organizations) without being asked. This happens only when the CNSC has serious concerns about the risk to health, safety, security and the environment. The advice is always provided to the organization that is responsible for the issue or action about which the CNSC is concerned. For example, if the CNSC is concerned about a licensee's recommendation to the off-site authorities, the CNSC provides advice to the licensee, not the off-site authority. Appropriate advice means making the other organization(s) aware of the CNSC's assessment and its concerns.

3. CNSC Fukushima Task Force Recommendations

On March 11, 2011, a magnitude 9.0 earthquake, followed by a devastating tsunami, struck Japan. The combined impact of the earthquake and tsunami on the Fukushima Daiichi nuclear power plant caused a loss of power which led to a severe nuclear accident. The CNSC responded immediately to the accident at Fukushima Daiichi with the following actions:

1. Activation of its Emergency Operations Centre in Ottawa and staffing it 24 hours a day, 7 days a week, to monitor the emergency, assess early reports and provide timely, accurate information to Canadians and to other Canadian government departments and agencies;
2. Requesting licensees of Canadian Class I nuclear facilities, under section 12(2) of the *General Nuclear Safety and Control Regulations*, to review the lessons learned from the Fukushima Daiichi accident;
3. Performing inspections of all NPPs and other nuclear facilities in Canada to assess the readiness of mitigation systems. These inspections covered seismic preparedness, firefighting capability, backup power sources, hydrogen mitigation and irradiated fuel bay cooling; and
4. Establishing a Task Force to evaluate the operational, technical and regulatory implications of the accident and the adequacy of emergency preparedness for NPPs.

In the aftermath of the Fukushima incident, the Emergency Management Programs Division (EMPD) within the CNSC prepared a report [1] with several recommendations. With respect to the EOC Technical Support Team, the following five action items resulted:

1. Action Item 13: Ensure technical applications (e.g. modeling software) can be run from the EOC. All modeling capabilities should be in-house driven and not dependent on external stakeholders;
2. Action Item 16: Prepare hardcopy and e-version reference packages for all Canadian reactor sites. The e-versions should be stand-alone repository available on an external hard drive in the EOC;
3. Action Item 27: Develop a "library" of source term information for Canadian reactors;
4. Action Item 28: Develop the capability to review and validate licensee source term estimates;
5. Action Item 29: Acquire tools and develop and maintain the capability for source term and dispersion modeling, in line with the licensee's, the provincial's and Health Canada's capability.

The Action Items listed above are part of a larger pool of recommendations presented to the commission [1].

4. EOC Technical Team Support Project

In response to the 5 action items, the Reactor Behaviour Division (RBD) within the Directorate of Assessment and Analysis (DAA) initiated the EOC Technical Support Team Project. The project is comprised of three independent yet interlinked projects: EOC Technical Support Team Information Project, NPP Accident Handbook, and EOC Source Term Project.

4.1 EOC Technical Support Team Information Project

Among the lessons learnt from the EOC activity during the Fukushima Accident was the need for essential technical support information to be available to the Technical Support Team. This includes plant layout and drawings, operating parameters and safety analyses for all existing CANDU NPPs and for other nuclear facilities where nuclear accidents may occur. It is expected that the required information would be readily available so that in an event of an incident or exercise no time would be lost searching for documents. The information is to be available in both a hardcopy and a softcopy format.

4.2 NPP Accident Handbook

The Nuclear Power Plant (NPP) Accident Handbook project was initiated to provide easily accessible reference material for technical staff involved in EOC operations. The handbook project takes the results of the EOC Technical Team Information Project and packages

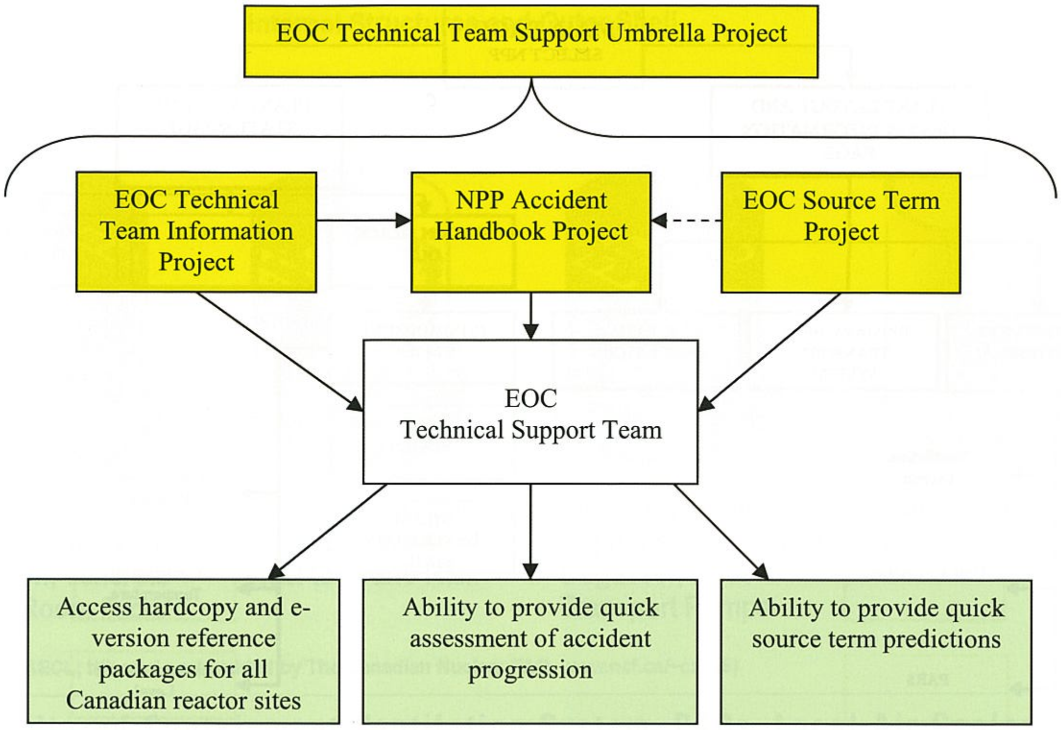


Figure 1: EOC Project Integration.

the essential information into a user friendly database computer program. Although the information provided to the technical staff through the information project will be complete, it must be recognized that the information will be extensive in volume and arduous to navigate through. The NPP Accident Handbook will allow technical staff to find site-specific and accident-specific details that will allow them to provide expert advice to the EOC team during an accident progression.

4.3 EOC Source Term

The third component of the EOC Technical Team Support Project is the EOC Source Term. The EOC Source Term Project will provide technical staff with the capability of determining, in a short period of time, the radioactive source term and associated dose (both on-site and off-site) for a particular accident scenario at any CANDU facility in Canada. The project requires that two independent tools be employed; one should be from the industry toolset in order to confirm the licensee's predictions, and the second should be a CNSC tool to provide an independent evaluation of dose and source term.

The industry tool for source term calculations is the Canadian code Emergency Response Projection (ERP) developed by AMEC-NSS. ERP is the tool used at all of the Ontario Nuclear Power Plants (NPPs) as well as Emergency Management Ontario. However, an adequate industry independent source term code for CANDU NPPs is not available. As such, the focus of the EOC Source Term Project is to develop an independent source term software tool for CNSC staff.

4.4 Project Integration

Although the three projects are listed as separate entities, they support and compliment each other in achieving the main goal; ensuring the Technical Support Team has the proper tools to fully assist the EOC team during emergency operations. Figure 1 below illustrates the inter-relationship between the three projects.

As can be seen from Figure 1, the EOC Technical Support Team Information Project will firstly provide access to hardcopies and electronic-version reference material for the EOC team. Secondly, it will provide selected key information for inclusion in the NPP Accident Handbook. The EOC Source Term project will satisfy the requirement for a capability to review and validate licensee source term estimates. The dotted line in Figure 1 illustrates a future initiative that would involve using source term estimates in the NPP Accident Handbook, or even linking the two codes. However, that is presently outside the scope of the project.

5. NPP Accident Handbook Prototype

The NPP Accident Handbook Prototype is currently under development at AECL Chalk River Laboratories and CNSC offices in Ottawa. The initial work focuses on the Point Lepreau Generating Station due to the readily available data for that station. New Brunswick Power completed a comprehensive list of analysis of Beyond Design Basis Accidents (BDBA) for PLGS in

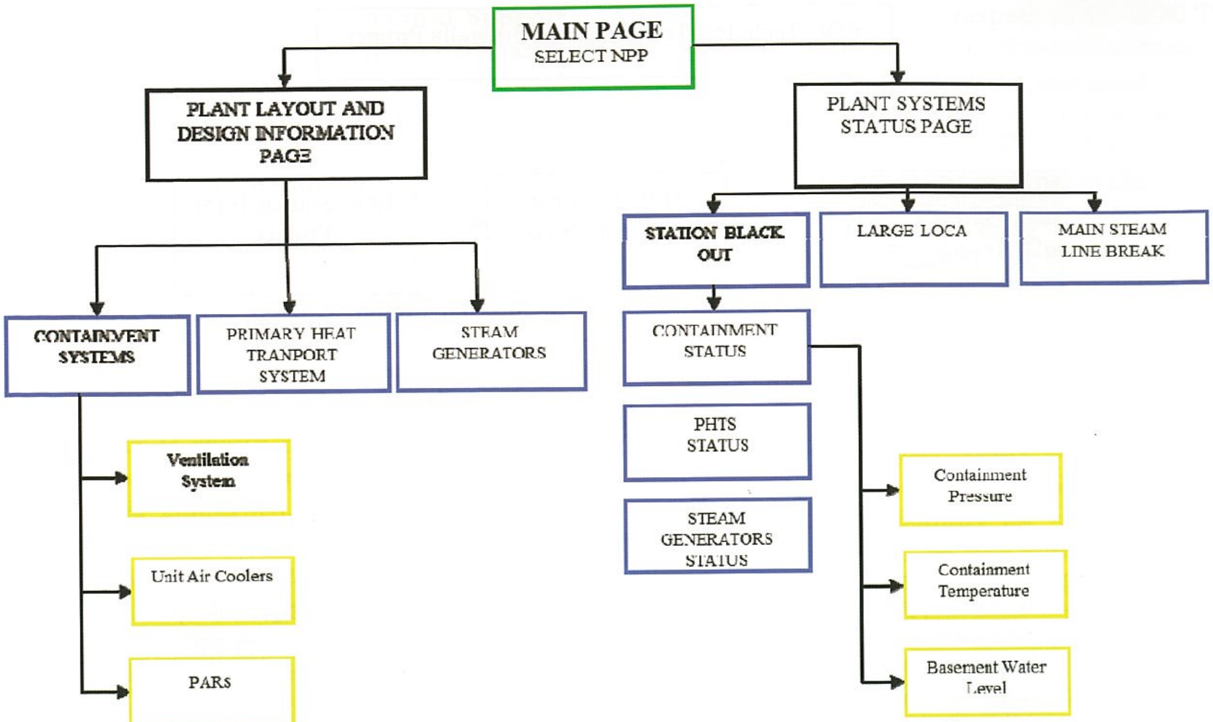


Figure 2: NPP Accident Handbook Layout.

2008. These analyses were carried out using the severe accident analysis code MAAP4-CANDU.

The handbook is divided into two components; Plant Layout and Design Information, and Plant Systems Status as illustrated in Figure 2. Upon selecting the desired power plant on the main page, the user then can a) view plant layout and design information or b) search through the database of pre-calculated accident analyses. For example, after selecting the Plant Status Page, the user can choose from a list of accident scenarios. It should be noted that Figure 2 is for illustration purposes and many more accident scenarios will be available. Once the user has selected an accident scenario, a particular system can be explored. In the case shown in Figure 2, the Containment Status has been selected and is showing various system specific parameters that are available for viewing. If the user were to further select the Containment Pressure button, a graph showing the containment pressure versus time would be displayed, as illustrated in Figure 3.

The Plant Systems Status component has a completed prototype which is presently undergoing review from key stakeholders from within the CNSC and industry. The feedback from this review will assist in defining

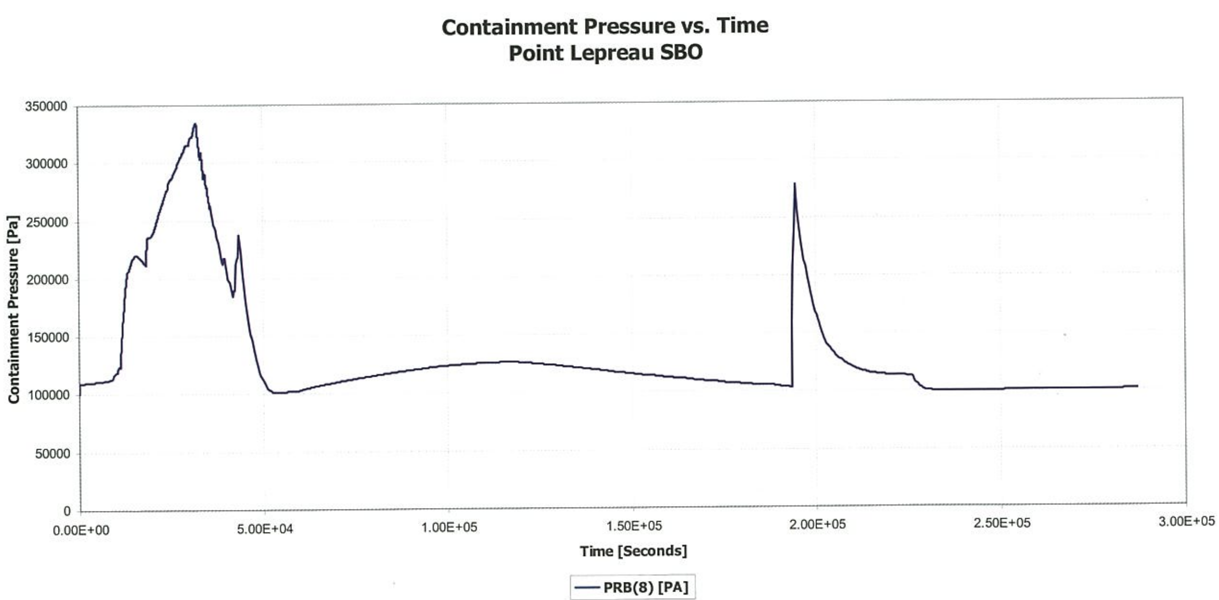
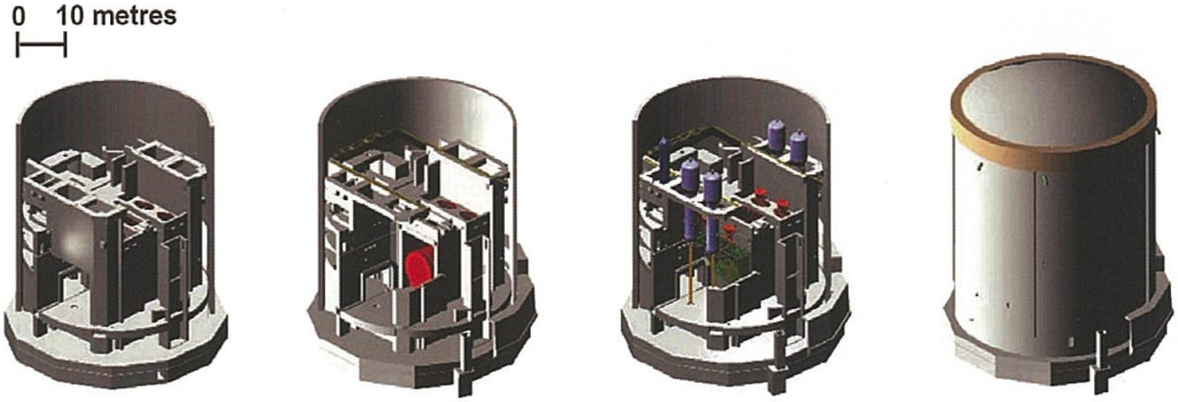


Figure 3: Typical System Status Data.

CANDU 6 Containment: Internal Structures and Outer Shell



Steam Generator Enclosure to 125 m elevation, concrete Pump Room floors

Tubed Calandria in vault. Structural steel to Crane Rail.

Steam Generators & Supports, Pressurizer/ Degasser, Heat Transport Pumps

Concrete to Upper Dome

(Source: AECL; title and scale added by The Canadian Nuclear FAQ, www.ncf.ca/~cz725)

Filtered Containment Ventilation System, PARs, Local Air Coolers

Figure 4: Typical Plant Layout and Design Information Available.

the look and feel of the final version. Although the prototype has been developed under a simple HTML format, it is anticipated that the final product will be developed under a Graphical User Interface (GUI) software application such as Java. As the software will not perform detailed calculations, there is no requirement to employ a hard engineering code such as FORTRAN or C++. The Handbook will have the feel of an easy to navigate webpage. Behind the GUI will be the necessary drawings, databases and calculations.

If it is desired to know more about a particular system in terms of design and layout, the user would select the Plant Layout and Design button in Figure 2 and then choose the appropriate system. Selection of Containment Systems would bring up the technical specification page on the containment system with options for more details on specific systems within the containment such as the Passive Autocatalytic Recombiners (PARs) or the Unit Air Coolers, as illustrated in Figure 4.

The Plant Layout and Design Information component is being developed through the EOC Technical Support Team Information Project by CNSC staff and will be completed by the fall of 2012.

The Handbook allows the user to select a previously-assessed accident that would closely resemble an actual incident at the plant. As it is impossible to simulate each and every accident scenario a selection of scenarios are made available to the user. The user is then required to have a minimum technical expertise in choosing an appropriate accident case. The user is expected to interpret the results in light of the fact that the selected case may not exactly represent the actual situation. The limitations of the Handbook are overcome through user experience, and the ability of the user to review other similar accident scenarios and interpret the results to the existing situation.

6. Conclusion

The CNSC is committed to the resolution of all actions items recommended by the Fukushima Task Force. In an effort to improve the performance of the EOC technical team during emergency operations, five action items were initiated by the task force. These five action items will be resolved through the EOC Technical Team Support Project. This umbrella project comprises 3 independent yet interlinked projects that will further improve the technical team's ability to respond to the EOC team's questions effectively and efficiently. One of the main tools being developed within the EOC Technical Team Project is the NPP Accident Handbook (the Handbook). The Handbook is being developed through a cooperative agreement between CNSC and AECL-CRL. The Handbook allows CNSC technical staff to find site-specific and accident- specific details that will assist them in providing expert advice to the EOC team during an accident progression. The program is in the prototype stage and is currently using Point Lepreau Nuclear Generating Station as the trial station.

It is anticipated that the NPP Accident Handbook will, in due course, include all nuclear power plants in Canada, and may eventually include non power reactors as well. During the prototype phase, the CNSC and AECL are encouraging feedback from the industry and key stakeholders. It should be emphasized that the NPP Accident Handbook is intended for CNSC internal use only. However, in order for it to be an effective tool, it must reflect reality and should not contradict tools presently in service in the Canadian nuclear industry.

7. References

[1] CNSC Internal Document, "Fukushima Nuclear Emergency, EOC Improvement Plant", Version 2, July 2011.

[2] CNSC Emergency Response Plan, CAN2-1, Revision 6, December 2010.

Spent Fuel Response after a Postulated Loss of Spent Fuel Bay Cooling Accident

by H.Z. FAN, R. ABOUD, E. CHOY, W. ZHU, AND H. LIU[1]

[Ed. Note: The following paper was presented at the 33rd Annual Conference of the Canadian Nuclear Society, held in Saskatoon SK, 10-13 June 2012.]

Abstract

A study of the spent fuel behavior in a postulated severe accident is performed to understand the timings of actions and potential consequence associated with an unmitigated loss of cooling for an extended period of time. This study provides input to the "stress test" for Cernavoda CANDU® 6 plants, requested by WENRA/ENSREG. For extreme situations, in the light of the events which occurred at Fukushima in 2011, this work has assessed the spent fuel response after a postulated loss of spent fuel bay cooling accident, assuming that there is a prolonged loss of all electrical power and water make-up to the spent fuel bay. Assessment results indicate that hydrogen generation is insignificant as long as the spent fuel remains submerged. With a large amount of shield water in the CANDU spent fuel bay, as a passive inherent feature, it is estimated that the onset of spent fuel uncovering takes more than two weeks after loss of the spent fuel bay cooling for the spent fuel bay design with normal load. The potential consequence is also discussed after the water level drops below the first few layers of spent fuel bundles due to boil-off/evaporation. However, there is a significant amount of time to take corrective actions using a number of backup design provisions to prevent spent fuel bundle uncovering.

1. Introduction

Considering the accident at the Fukushima nuclear power plant in Japan in 2011, the Council of the European Union declared that the safety of all European Union nuclear plants should be reviewed, on the basis of a comprehensive and transparent risk assessment ("stress tests") [1][2]. The WENRA stress test is defined as a targeted reassessment of the safety margins of nuclear power plants in extreme natural events challenging the plant safety functions and leading to a severe accident. In these extreme situations, sequential loss of the lines of defence is assumed, in a deterministic approach, irrespective of the probability of this loss.

As a subtask of WENRA stress test for Cernavoda CANDU 6 plants, the spent fuel bay (SFB) is one of the reassessment targets. For extreme situations, in the light of the events which occurred at Fukushima in 2011, it is assumed that there is a prolonged loss of all electrical power and water make-up to the spent fuel bay. Hence, for this work, a loss of spent fuel bay cooling accident is postulated.

The spent fuel bay for Cernavoda CANDU 6 plants is built below ground level and designed to prevent SFB water drain for design basis accidents with a sufficient margin. The spent fuel bay has a liner system (e.g., stainless steel liner for Cernavoda 2) to provide an impermeable membrane that creates a leak tight boundary to prevent seepage and loss of water from the spent fuel bay. Therefore, SFB leakage or drainage due to severe accident conditions is not postulated. In this subtask of stress tests, the study is on spent fuel response due to the loss of SFB cooling.

1 (hazen.fan@candu.com)
Candu Energy Inc., Mississauga, Ontario, Canada

® Registered trademark of Atomic Energy of Canada Limited, used under exclusive license by Candu Energy Inc. (Candu).

2. Event and Assessment Performed

In this study, a loss of spent fuel bay cooling event is postulated where it is assumed that there is a prolonged loss of all electrical power and water make-up to the spent fuel bay. During this severe accident event for a CANDU 6 plant, the spent fuel bay water would gradually heat up under the spent fuel decay power.

The topics of the study at certain event stages are described as follows:

1. When will the spent fuel bay water start boiling, given the volume of water and the number of spent fuel bundles in the bay;
2. When will the level of the spent fuel bay water reach the top row of the spent fuel bundle stack to start uncovering the fuel;
3. Once the top layers of fuel bundles are exposed to steam and air, what is the potential for hydrogen generation, if any; and
4. How long will it take for the entire inventory of spent fuel bay water to boil off?

These study results will provide the information about the time available to re-supply the electrical power or to find alternate sources of water to the spent fuel bay before significant hydrogen is generated. It has to be pointed out that several spent fuel bay measurements are provided at the CANDU 6 station. Such indications are given at the local panel and on the station computers in the main control room, backed up with emergency power systems, to monitor and alarm the bay water abnormal levels, temperatures, and coolant flow for the operator to take actions in a timely manner. These measurements are not credited in this work.

3. Spent Fuel Bay Systems and Assessment Assumptions

3.1 Spent Fuel Bay Systems

The SFB is a rectangular pool for the CANDU 6 reactor (Figure 1). The spent fuel storage bay contains stainless steel storage trays (racks) to hold spent fuel bundles (Figure 2). The storage tray is designed to permit the free flow of bay water for cooling the spent fuel bundles, and is capable of supporting in a stable manner, from 1 to 24 fuel bundles in the same layer during storage and/or transfer of the trays. The tray is made of ANSI 304L stainless steel with a layout height slightly larger than the spent fuel bundle diameter.

The trays and supports are designed with sufficient structural stability to avoid toppling and prevent sliding of the stacks either prior to or after a design basis earthquake. The supports also provide the clearance between the bottom layer of fuel bundles and the bay floor, and permits flow of water around the trays.

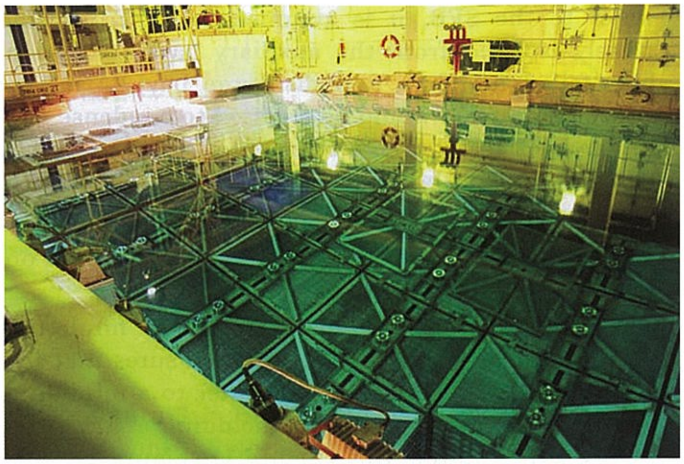


Figure 1: CANDU 6 Spent Fuel Bay Overview.

Figure 2: Storage Trays in Spent Fuel Bay.

The spent fuel bay has a 6-inch diameter supply line from the hydrants fire protection system provided in case of emergency. Note that there is no need to add neutron absorbing poison to the fuel bay water or make-up water as there is no criticality concern for natural uranium spent fuel in light water. This makes the post-accident tasks for a CANDU reactor simpler.

The normal discharge of 8 bundles per refuelling cycle requires three cycles to completely fill a storage tray with a 24-bundle capacity (Figure 2). When the storage tray is full, it is temporarily stored in the reception bay which has a storage capacity of four trays. The storage trays are transferred individually to the SFB, and placed on the base supports located on the bay floor. Trays may be stacked up to a height of 19 layers per stack. Cernavoda Unit 1 is operated with up to 19 layers per stack, while Cernavoda Unit 2 is operated with up to 18 layers per stack.

In this study, the following key assumptions are made for the spent fuel bay systems:

- No make-up water is supplied to the spent fuel bay after the initiation of event

In additional to the stoppage of circulated cooling water to the SFB, it is assumed the SFB is completely isolated from the auxiliary bays (reception bay, failed fuel bay, and discharge bay). Also, no evaporated steam would be credited to condense and return back to the bay. These assumptions conservatively minimize the available inventory for the SFB, and underestimate the time to SFB water boiling.

- The minimum shield water volume used is based on the design requirement of the safety marker.

  The spent fuel bay is operated with a minimum shield water depth of 4.5 m, which ensures that the fuel load shall be immersed in water to a minimum depth of 4.11 m at all times including a tray passing over the top fuel tray (Figure 1) (Figure 2). This gives the minimum shielding water volume of slightly over 1000 m^3 covering all the spent fuel bundles, and provides the passive inherent feature to mitigate or delay the consequence of loss of SFB cooling.

- It is assumed that the each tray layer in the bay is completed filled with spent fuel bundles.

  It is assumed that each tray has a full load (i.e., 24 fuel bundles per tray) for all 112 tray stacks, yielding 2688 bundles per tray layer. During operation, the first two rows of tray stacks are left empty for dry storage equipment. However, assuming these rows are also filled with bundles is conservative with respect to boiling, since the ratio of the bay water volume to the fuel bundle volume is minimized. Hence, the solid materials (mainly bundles and trays) per layer would occupy space up to about 8.42 m^3. There is a gross volume of 32.2 m^3 for each tray layer. Therefore, the water volume would have at least 23.8 m^3 per layer, which still indicates that CANDU 6 SFB has a large ratio of water volume to the spent fuel volume per layer.

- Designed normal heat load in the SFB is assumed.

  The spent fuel bay cooling system is designed for a normal heat load of 2 MW, which is used in this study (2 MW case). This is primarily based on the removal of decay heat from 10 years of accumulation of spent fuel at an 80% load factor, which is less than 2 MW(th). Transfer to dry spent fuel storage will start after they have been cooled in the bay for about 7 years with the bundle power of about 6 W or below. Therefore, this 2 MW case assumption conservatively maximizes the total normal heat load in the spent fuel bay for determining the time to water boiling. For other heat loads such as emergency core unload are not postulated.

- Limited heat removal mechanisms are considered.

  To conservatively minimize the time to onset of boiling, bay water heat removal is considered only by bay water evaporation. Other heat transfer mechanisms such as the heat stored in the spent fuel and heat lost through the bay wall and floor are not credited.

These key assumptions set up reasonable worse-case SFB conditions (i.e., less water inventory and more heat load) to assess the spent fuel response after a postulated loss of spent fuel bay cooling accident.

3.2 Spent Fuel Bay Room

The spent fuel bay room is a single-storey structure which forms part of the service building structural complex, and is qualified against wind and seismic events. The SFB exhaust system filters exhaust through its own high efficiency filter bank to remove all forms of radioiodine that might be present in the SFB room, prior to discharge via the stack by venting systems or natural venting due to stack effects. It has been estimated for this work that the SFB room volume above the ground is about 3000 m^3. This SFB room volume will be used to assess potential hydrogen concentration. Note that the SFB room has a relatively large ratio of total water to space (roughly about 1:2) upon onset of boiling of the SFB water.

3.3 Decay Power

The spent fuel bundle power varies with discharge age as the power decays from the power level in the core prior to discharge. Table 1 lists average decay power values, which is acceptable for a severe accident, such as in this study of postulated loss of SFB cooling.

The fuel bundle power in general varies in the core over a wide range up to 800 kW at the nominal design level. With a normal CANDU 6 refuelling process, about one third of fuel bundles have a discharge power above 600 kW, and 80% above 300 kW.

The spent fuel bay heat load mainly comes from spent fuel discharged in recent years, about 50% and 80% for that within one year and three years, respectively. While the average bundle power for the

Table 1: Long Term Decay Power

Decay time (s)	Decay Time	Normalized Decay Power	Design Bundle Power (kW)	Typical Bundle Power (kW)
0.0	Leaving the core	1.000000000	800.0	600.0
2.59E+05	3 days	0.003800000	3.040	2.280
1.00E+06	11.6 days	0.001940000	1.552	1.164
2.59E+06	1 month	0.001180000	0.944	0.708
1.00E+07	4 months	0.000500000	0.400	0.300
3.15E+07	1 year	0.000174800	0.140	0.105
1.00E+08	3.2 years	0.000043320	0.035	0.026
1.58E+08	5 years	0.000022740	0.018	0.014
3.15E+08	10 years	0.000013942	0.011	0.008

2 MW case is about 0.0426 kW, the power of recently discharged bundles in the SFB is significantly higher than that. Based on the decay power profile and discharge power level, it is estimated that there are about 200 bundles with the power higher than 0.600 kW among recently discharged within 10 weeks (about 900 bundles). The SFB is designed to hold a total of over 45,000 spent fuel bundles. The accumulation rate of spent fuel bundles in the SFB is about 90 bundles/week. Within a month of decay, all of the bundle powers are below 1.0 kW, and within three years of decay, all of the bundle powers are below 0.0426 kW (the average bundle power in the SFB of 2 MW case).

3.4 Hydrogen Generation

Hydrogen (H2) generation is due to sheath oxidation in steam (Zr/steam reaction), when the sheath (Zr) is hot enough, sufficient steam (H2O) is present, and the reaction is accompanied by additional heat generation (Q):

$$Zr + 2\ H_2O = ZrO_2 + 2\ H_2 + Q$$

The Urbanic & Heidrick correlations [3] are established and validated for Zr/steam reaction calculation. It indicates the key temperature ranges:

- Onset temperature: 827 °C
- Transition temperature: 1577 °C
- Fast reaction temperature: >1850 °C

Hydrogen generation for different bundle powers will start when the sheath temperature reaches 827 C. When there is no additional notable heat removal from the fuel sheath, Zr/steam reaction has a positive feedback on the fuel temperature until all of the sheath material or steam is consumed. There is about 2.21 kg of Zirconium material per bundle (about 2 kg for sheath, the rest for the endplates and appendages) or 24.2 mol per bundle. Zirconium has the molecular weight of 91.22 g/mol. Hence, each bundle has a potential to generate up to 48.5 mol of hydrogen (H2).

Hydrogen would also be produced due to radiolysis, in the process of water being dissolved by radiation in a spent nuclear fuel pool experiencing boiling. This has been postulated as one of hydrogen sources at Fukushima nuclear reactor Unit 4, while the main hydrogen source would be from adjacent units. Gas generation by radiolytic decomposition of hydrogen-containing materials has been an area of concern for the transport and storage of radioactive materials and waste for a number of years. Potentially combustible and corrosive gases can be generated while at the same time, chemical reactions can remove hydrogen, and these reactions can be enhanced by the presence of radiation. The balance between these competing reactions is not well known at this time. It is also understood that the radiolysis process is relatively slow and needs high-energy flux. CANDU spent fuel bundles generate relatively low-energy fluxes under the water.

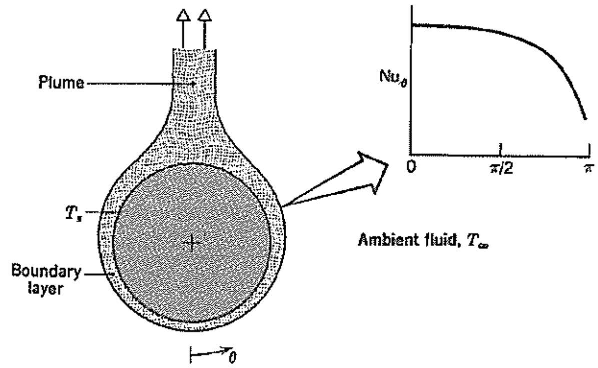


Figure 3: An Idealized Cooling for a Long Horizontal Cylinder Based on Reference [4].

Therefore, it is expected that hydrogen generation is insignificant if there is available shielding water in chemical equilibrium which is provided in the spent fuel bay until the top of the spent fuel is uncovered. However, with bundles exposed to the steam, it is expected that radiolysis would induce a hydrogen source, even through relatively small and slow, in additional to Zr/steam reaction.

3.5 Assessment Approaches

Prior to spent fuel uncovering, the spent bay water boiling is assessed with total water inventory and total bulk power of spent fuel. With the key assumptions given in Section 3.1, a simple hand calculation can be used based on the mass and heat balances.

After spent fuel uncovering, these spent fuel bundles are subject to steam cooling and radiation heat removal with complicated surrounding conditions. The approach with a long horizontal cylinder [4] would be taken accounting for natural convection process (Figure 3) and radiation effects to assess the maximum heat removal for the potential of the onset of hydrogen generation.

Another approach would be taken using the CATHENA computer code [5]. Figure 4 shows the CATHENA model established for assessing fuel response to loss of spent fuel bay cooling. A hydraulic component (BDLA1 in Figure 4) represents the bay water or steam at the top layer. This component is connected to hydraulic components (PIPE99 and OUTLET in Figure 4) above for the SFB room environment, and a hydraulic component (INLET in Figure 4) underneath for the heat and steam conditions provided from underneath the fuel bundles and the bay water. A set of fuel wall models with a specified bundle power can be attached to this hydraulic component to assess fuel response during and after the surrounding water boil-off. With these fuel wall models, the effects of both convection process and radiation heat transfer toward the surrounding tray and supporting material, as well as potential Zr/steam reaction for hydrogen

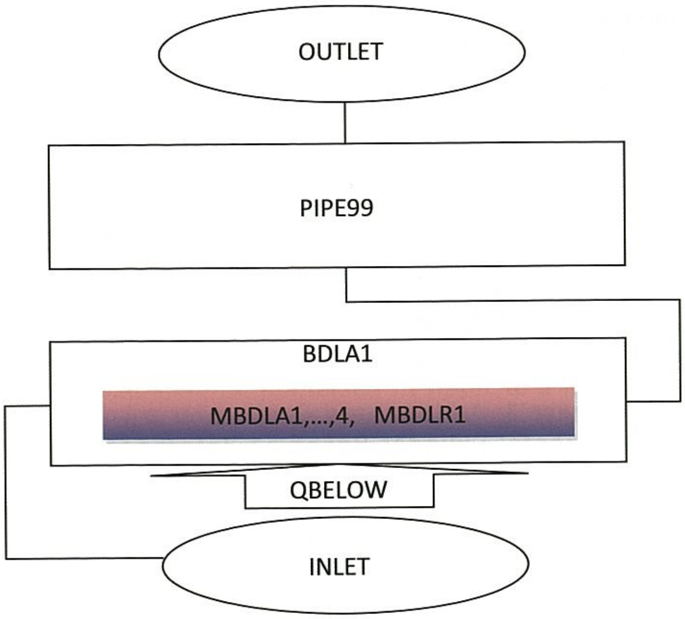


Figure 4: CATHENA Model to Assess Fuel Response to Loss of Spent Fuel Bay Cooling.

generation, can be accounted for. The remaining fuel wall model (MBDLR1 in Figure 4) represents the rest of the bulk fuel bundles at the same layer with an average bundle power.

4. Assessment Results

4.1 Onset of Spent Fuel Bay Water Boiling

Based on minimum bay water volume and maximum operating temperature, onset of the spent fuel bay water boiling for the 2 MW case has been estimated at 60 h 23 min, or about 2.5 days, after loss of the spent fuel bay cooling (Table 2). This estimation has assumed that the SFB has a net water volume of about 1600 m^3 with initial water temperature of 38 °C for the normal operating conditions. The shield water depth is still maintained by the time onset of boiling occurs.

With the bay water covering the spent fuel, the spent fuel is expected to stay in the nucleate boiling even if the water has zero subcooling (i.e., reached the boiling point). In the SFB, the highest spent fuel bundle power is about 10 kW (Table 1), considering the decay time of fuel handling process from the core to the reception bay then to the SFB. Such spent fuel needs heat removal flux of only about 15 kW/m^2, which is much lower than the critical heat flux, CHF (over 600 kW/m^2) estimated for the bay pool water. Hence, all spent fuel temperatures are just slightly higher (a few degrees in Kelvin at the most) than the bay saturation temperature (100 °C), but the heat flux is well below the CHF value.

No Zr/steam reaction is expected for sheath temperature lower than 827°C (Section 3.4) prior to spent fuel bundle uncovering. By this time, it is also expected that hydrogen generation due to radiolysis is insignificant as available shielding water remaining in chemical equilibrium and low-energy flux from CANDU spent fuel bundles, as discussed in Section 3.4.

4.2 Onset of Spent Fuel Bundle Uncovering

As the spent fuel bay water is heating up and boiling off, the water level in the spent fuel bay will start to decrease. Prior to the top row of the spent fuel becoming exposed to steam and air, all fuel bundles are at temperatures just slightly higher than the bay water temperature.

After onset of boiling, the spent fuel bay heat removal mainly depends on the bay water evaporation. The water available for evaporation prior to the onset of uncovering is conservatively based on the low limit

Table 2: Estimated Uncover Time for Top Layer

	Bay Water Surface Area (m^2)	Shielding Water Depth (m)	Cover Water Volume (m^3)	Cover Water Evaporation time (days)	Onset of Boiling (days)*	Minimum Decay days**	Notes
2 MW case	235.90	4.50	1061.5	13.28	2.50	15.8	19 trays (Unit 1)
2 MW case	235.90	4.64	1093.8	13.68	2.50	16.2	18 trays (Unit 2)

Safety marker	4.11	m
Shielding water for 19 trays	4.50	m
H Evaporation		
= HG-HF = 2.675-0.419	2.26	MJ/kg
Density	958	kg/m^3
tray height	136.65	mm
* Onset boiling time	60h 23 min (2.50 days)	

** Minimum decay time accounting for normal discharge just out of the core upon loss of SFB cooling of shield water depth (4.5 m above the top bundles), which gives a water volume of about 1000 m^3, as discussed in Section 3.1.

For the SFB as an open pool, the enthalpies for water liquid and steam are 2.675 MJ/kg and 0.419 MJ/kg, respectively. Hence, the heat removal due to evaporation after onset of boiling is about 2.26 MJ/kg. The onset of uncovering will take longer time for sites with 18 stacks, as more shielding water is available for evaporation (Table 2). It should be noted that to remove 2 MW power, a continuous water make-up of about 0.89 kg/s can maintain the bay water level.

Given the inventory of water and the heat load to the spent fuel bay water, it is calculated that the boiling of the spent fuel bay water will commence at approximately 2.5 days after the event initiation for 2 MW case. Based on evaporation enthalpy and the heat load, it is calculated that it will take an additional 13.3 days for the water to boil-off where the top row of fuel bundles will start to get uncovered for the 2 MW case (Table 2). At this point, 15.8 days after the event initiation, sufficient pool water cooling will not be available for the top spent fuel bundles.

4.3 Bay Water Boiling-Off

With more fuel bundles uncovered, the bay water boiling slows down. Only these bundles remaining submerged in the bay water would be the heat source to boil the bay water. The number of the spent fuel bundles remaining submerged in the bay water is about proportional to the SFB water level. Hence, the decay power, directly heating the SFB water is assumed proportional to the remaining SFB water inventory. Similar to the estimation of onset of boiling and uncovering, bay water heat removal other than evaporation is not considered to analytically assess the time of bay water boiling-off process.

For the SFB water with 2 MW and 18-trays stack height upon the onset of uncovering, it takes about 7.36 hours to have the top layer of water boiled-off. The SFB water boiling-off slows down with more bundles uncovered. To have the top three layers of water boiled-off, it takes about 23.5 hours. If the full power would continuously heat the remaining bay water, it would take about another 5.37 days to have the low level layers uncovered. With the decreasing power in fact heating the remaining bay water and considering high ratio (about 1:2) of water to space in the SFB room (Section 3.2) and other environment cooling and condensation effects, it is expected that the SFB water would take a long time in days, if not weeks, to have the low level layers uncovered. There are some residual water without direct heating remaining in the bay underneath all of the bundles, since storage trays are placed on the supports about 0.20 m above the bay floor. Also, it is expected that moisture content in the spent fuel bay room is extremely high by onset of boiling, such that some steam can return to the bay by 'raining' or 'fogging'.

However, whether the SFB continues boiling off may not be relevant to assess further for hydrogen generation and other consequences, as the idealized boiling conditions would not exist if there would be a potential with high temperatures of the uncovered spent fuel bundles and their supports.

4.4 Response of Uncovered Spent fuel

Not all uncovered spent fuel would heat up rapidly and reach a high temperature. The heat transfer is driven by natural convection process, which can be either laminar or turbulent, plus the radiation effect to the surroundings. It is estimated that with an ambient temperature of 100 °C, when a spent fuel bundle reaches 500 °C, the total heat removal would be around 1.5 kW. The heat removal rate is greater than any spent fuel bundle power after 2 weeks in the bay. It is checked by either the approach with a long horizontal cylinder (Figure 3) or the approach using CATHENA model (Figure 4). Such ambient surrounding conditions (Figure 3) would be applicable to the spent fuel bundles just above the water or near the edges of trays. Therefore, no immediate hydrogen generation would occur with onset of the spent fuel uncovering.

Once the level of the spent fuel bay water drops to below the first layer of spent fuel bundles, the ambient surrounding conditions gradually change to that with superheat steam and hot adjacent bundles/trays. The extent of temperature changes of some high power spent fuel and potential hydrogen generation would be assessed with both approaches as discussed in Section 3.5, providing more detailed assumptions on complicated heat transfer. However, by this stage after a postulated prolonged and unmitigated loss of spent fuel bay cooling, there would be a potential for the consequence getting worse.

4.5 Discussion on Potential Consequence and Prevention Mitigation Actions

Based on the above assessments, with a large amount of shield water in the CANDU spent fuel bay, as a passive inherent feature, it is expected that there would be no cliff-edge effects, till onset of spent fuel uncovering, for a long period (i.e. 15.8 days for 2 MW and 4.5 m shield water depth) after the loss of the spent fuel bay cooling for the spent fuel bay design with normal load. There would be another additional day wherein the spent fuel remains intact with stabilized convection (water or steam/air) and radiation heat removal.

If make-up continues to be unavailable, with multi layers of spent fuel uncovered over days or weeks, there would be a potential for the consequence getting worse (cliff-edge effects), which are briefly discussed as follows.

The tray can maintain its structural function to support bundles up to about 500 °C based on its stainless steel material strength. With radiation and contact heat transfer effects from the high power bundles which are uncovered, some parts of the tray would heat up beyond this temperature and experience a loss of integrity. The similar structure failure would occur in the uncovered portions of the tray supports.

With the surrounding environment getting hot, it could not be precluded that some spent fuel temperatures would increase substantially as there is less cooling available. Hence, onset of Zirconium-steam reaction with hydrogen generation could occur, accompanied with Zirconium-air reaction which does not produce hydrogen.

With prolonged high temperature and heavy oxidation (whether in steam or in air), the fuel sheath might not be able to maintain its integrity to retain the fission product inventory inside. Furthermore, with bundles exposed to the steam and significant fission product release from failed fuel bundles, it is expected that radiolysis would induce an additional and continuous hydrogen source, even through relatively small and slower compared with Zr/steam reaction.

With spent fuel bay water boiling off, the generated steam and hydrogen would migrate to the upper parts of the spent fuel bay building room. The steam there would undergo condensation and drop down, but the hydrogen would be believed to have remained in gas form and increase its local concentration.

However, simple and effective mitigation measures can be taken to prevent these consequences getting worse by restoring power or providing cooling water into the spent fuel bay, preferably prior to spent fuel uncovering. Within a relatively long period after loss of the spent fuel bay cooling, the various types of actions could be taken, including supply of make-up water to the spent fuel bay using the normal demineralised water, back-up fire water system, and fire truck or mobile pump via 6-inch diameter supply line connections provided in the spent fuel bay design. As the SFB is still accessible, directly adding water into the bay is achievable to maintain the water level. Collecting condensed water back the SFB can also be considered.

5. Summary

With the passive inherent feature of the CANDU spent fuel bay, there is a significant amount of time to take corrective actions to prevent uncovering of the spent fuel bundles. It is estimated that the onset of uncovering takes more than two weeks after a loss of the spent fuel bay cooling for the spent fuel bay design heat load. Such estimation can be simply performed for different shield water depth and heat load based on the amount of spent fuel in the bay and decay ages.

Hydrogen generation is insignificant as long as the spent fuel remains submerged. The potential consequence is also discussed after the water level drops below the first few layers of spent fuel bundles due to boil-off/evaporation. However, there is a significant amount of time to take corrective actions using a number of backup design provisions to prevent spent fuel bundle uncovering. Based on the estimated boil-off rate, a water make-up rate of about 1 kg/s is sufficient to maintain the bay water level for the spent fuel bay normal load (2 MW) for evaporative cooling. The backup design options being considered include supplying make-up water to the spent fuel bay using the demineralised water, back-up fire water system, fire truck or mobile pump directly or via the 6 inch diameter supply line connections provided in the spent fuel bay design.

6. Acknowledgments

The authors would like to sincerely thank for Candu Energy staff, including P. Chan, B. Zhai, A. Siddiqi, T. Sissaoui, T. Nguyen, D. Rouben, T. Laurie, A. Manzer, D. Damario, J. Ballyk, J. Hopwood, S. Yu, B. Lekakh, A. Ranger, R. Zemdegs, and F. Yee, for their solid and valuable support for this work. The support from Cernavoda NPP staff is also greatly appreciated.

7. References

[1] Western European Nuclear Regulations' Association (WENRA) Website News, http://www.wenra.org/extra/news/?module_instance=1&id=29, 2011 March.

[2] Western European Nuclear Regulations' Association (WENRA) Website News, "Stress Tests Specifications Proposal by the WENRA Task Force", http://www.wenra.org/dynamaster/file_archive/110421/0ea2c97b35d658d73d1013f765e0c87d/StressTestsSpecifications2011-04-21.pdf, 2011 April

[3] V.F. Urbanic and T.R. Heidrick, "High Temperature Oxidation of Zircaloy-2 and Zircaloy-4 in Steam", Journal of Nuclear Materials, Vol. 75, pp. 251-261, 1978.

[4] F.P. Incropera, and D.P. DeWitt, "Fundamentals of Heat and Mass Transfer", Third Edition, John Welley & Sons, 1990.

[5] B. N. Hanna, "CATHENA: A thermalhydraulic Code for CANDU analysis," Nuclear Engineering and Design, Vol. 180, pages 113-131 (1998).

EC6 Safety Enhancement – Including Impact of Fukushima Lessons Learned

by STEPHEN YU, R. ZEMDEGS, S. BOYLE and M. SOULARD[1]

[Ed. Note: The following paper was presented at the 33rd Annual Conference of the Canadian Nuclear Society, held in Saskatoon SK, 10-13 June 2012.]

Abstract

The Enhanced CANDU®[1] 6 (EC6) is the new Generation III CANDU reactor design that meets the most up to date regulatory requirements and customer expectations. EC6 builds on the proven high performance design such as the Qinshan CANDU 6 units and has made improvements to safety and operational performance, and has incorporated extensive operational feedback including Fukushima. The Fukushima Dai-ichi March 11, 2011 event has demonstrated the importance of defence-in- depth considerations for beyond-design basis events, including severe accidents. The EC6 design is based on the defence-in-depth principles and provides further design features that address the lessons learned from Fukushima.

1. Introduction

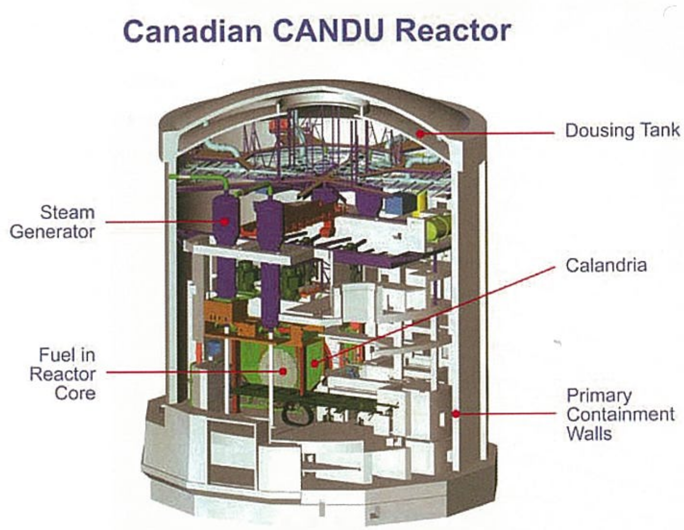
Proper application of defence-in-depth is the key in protecting the public against severe accidents, such as that which occurred at Fukushima. Two important aspects of defence-in-depth design provisions include: i) a high degree of robustness, which incorporates sufficient redundancy within the design and ii) a high degree of protection against a large range of accidents, including those whose probability is quite remote and which provide significant challenges for the reactor's ability to fulfill the key safety functions, namely to *control*, *cool*, *contain* and *monitor*. The CANDU design has been developed over many years and consists of attributes that i) prevent accidents, ii) if they occur, stop them and limit the consequences; iii) if they progress to core damage, provide protection and mitigate severe accident scenarios.

2. Proven CANDU Safety Features

The CANDU 6 is a proven high performance design that has continued to evolve with improvements up to the Qinshan CANDU units built in China. It has an appropriate combination of inherent, passive safety characteristics, and engineered and administrative safety features. These characteristics and features prevent and mitigate severe accident progressions.

CANDU reactors can be refuelled while operating, and incorporate safety features to respond to the safety requirements imposed by the Canadian Nuclear Safety Commission. Safety features include:

- a design that can use passive convection cooling for the primary systems to keep the reactor cool in the absence of power
- the use of a storage tank high in the containment building that work on gravity, which can also be used to replenish secondary side inventory and refill the steam generators, as required, to continue heat release in the event of a loss of power
- use of ceramic uranium fuel pellets that tolerate high temperatures
- two independent and diverse shutdown systems
- calandria (reactor core) vessel that contains the fuel bundles and heavy water moderator
- water filled calandria vault for shielding
- robust, reinforced concrete containment.



A strong contributor to the robustness and redundancy of CANDU design is the two-group separation philosophy. This ensures a high degree of independence between safety systems as well as physical separation and functional independence in how essential safety functions are provided. Two-group separation provides

1 Candu Energy Inc., Mississauga, Ontario, Canada (stephen.yu@candu.com)

2 Registered trademark of Atomic Energy of Canada Limited, used under exclusive license by Candu Energy Inc. (Candu).

two independent means of maintaining the essential safety functions for events which affect a limited area of the plant. Events with failure of a safety function in one group can be mitigated by the other group.

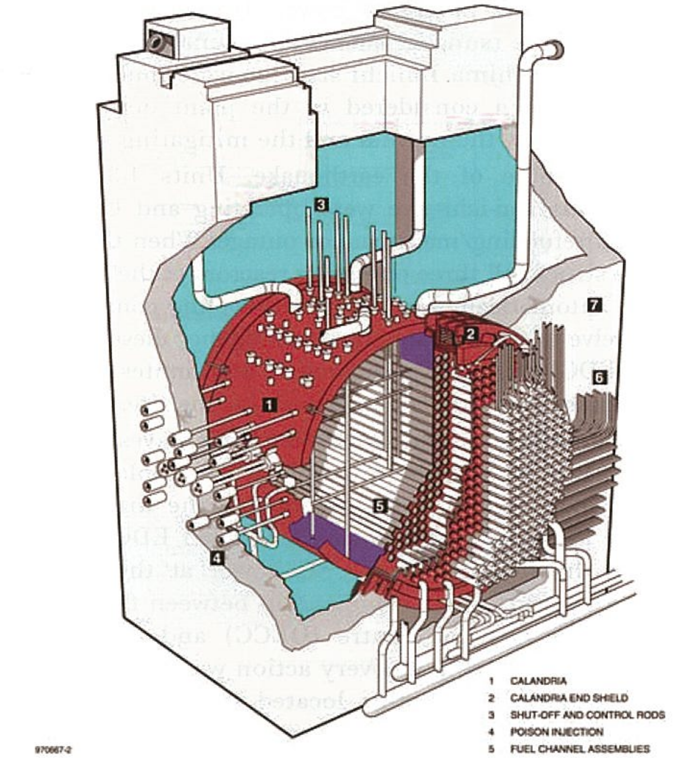
All CANDU reactors are designed with a number of barriers and protective systems that act to prevent releases of radioactive material into the environment. These include the fuel sheath, the heat transport system, the calandria tubes, the cool low pressure moderator, the cool low pressure shielding water in the calandria vault, the hydrogen control system and the containment building itself. The design measures taken result in a reactor that meets or exceeds regulatory requirements for the consequences of such accidents, with large margins that provide a high degree of robustness against accidents of even greater severity and correspondingly more remote probability of occurrence. These safety features further support the defence-in-depth strategy in establishing accident prevention as the first priority, as outlined in IAEA guide on Defence in Depth [1].

CANDU reactors have large inventories of water within or connected to the reactor building that are available to provide passive cooling, even during accidents in which electrical power is not available and that involve earthquakes and flooding, such as was the case in the Fukushima event. These include the quantities of water in systems that can be used for backup cooling or water in mitigation systems such as emergency core cooling and dousing:

- the heat transport system as reactor coolant,
- the calandria vessel as moderator coolant,
- the calandria vault as shielding water
- the high pressure emergency core cooling tanks,
- the dousing tank (CANDU 6)/reserve water tank (EC6)

In the EC 6® design, for example, these different water sources together come to over 3,000 metric tonnes of water available for passive heat removal. The large water inventories surrounding the fuel can passively remove decay heat from the fuel and the reactor core for many hours after an accident, providing time and opportunity for operator intervention. This is an important inherent safety feature of the CANDU reactors. The low temperature, low-pressure moderator in the calandria vessel surrounding the horizontal fuel channels provides an effective heat sink under some accident conditions, allowing the fuel channels to maintain their integrity even when internal cooling is not available. The water in the calandria vault normally used for shielding will provide continuous cooling of the calandria vessel, which may contain the core debris (molten corium), as long as it is submerged in the large volume of water in the calandria vault. [2]

The largest of these water inventories that can be used for heat removal is the water in the reserve water tank (2000 tonnes). This large volume of water is stored at



high elevation and so can be used to provide water by gravity feed to the secondary side of the reactor's steam generators. This water will then boil away and be released through steam valves in the secondary side and in the process will remove the decay heat of the reactor core. This passive cooling of the reactor using water already available in close proximity can be established using no electrical power at all, if necessary. Use of all of these different sources of water allows for a period of several days during which the operator can make use of emergency equipment such as portable diesel-driven pumps and electrical generators to maintain reactor cooling.

The water in the spent fuel storage bay is normally kept cooled by the bay cooling and purification system. On loss of power, the pool water will heat up and the fuel will continue to be cooled as long as the fuel bundles are submerged. There is significant time - about 16 days for operator to take corrective actions [3], and a small make-up rate of about 1kg/s will be sufficient to support evaporative cooling of the fuel in the storage bay.

Since CANDU reactors use natural (not enriched) uranium fuel, therefore light water can be used to provide cooling without concern for the fuel becoming critical. But for designs that use enriched fuel, appropriate chemical additions will be required to address criticality concerns.

3. Fukushima Events

On March 11, 2011, Japan suffered its highest recorded earthquake. A magnitude 9.0 earthquake struck off the eastern coast of Japan. It caused an immediate loss of offsite power. It also generated a series of large tsunami waves. The tsunami waves that hit the Fukushima Daiichi stations were much higher than had been considered in the plant design, and impacted both the normal and the mitigating systems.

At the time of the earthquake, Units 1-3 at the Fukushima Dai-ichi site were operating and Units 4-6 were in refuelling/maintenance outage. When the earthquake struck, all three operating reactors at the site shut down automatically and shutdown cooling commenced. All twelve of the available plant emergency diesel generators (EDG) started. Approximately 46 minutes after the earthquake, the first tsunami wave hit the site.

The flooding caused by the tsunami waves resulted in the loss of all nine available EDGs cooled by sea water and the loss of all but one of the three EDGs cooled by air. The remaining air-cooled EDG at Unit 6 was the only source of AC power at the six-unit site. All means of communication between the on-site Emergency Control Centre (OECC) and the on-site personnel executing recovery action was lost. The seawater pumps and motors located at the intake were destroyed; therefore the ultimate heat sink was lost.

4. Lessons Learned Identified from Major International and Canadian Reviews

The nuclear international community and regulatory organizations vigilantly reviewed the event to learn and improve nuclear safety. The common focus areas emerging from the compilation of lessons learned identified by the international organizations and regulatory bodies include external hazards, severe accident management and emergency preparedness.

The Japanese Reports by the Government of Japan [4] identified lessons learned to strengthen measures against earthquakes and tsunamis. In its mission report [5], the IAEA identified that response to a severe accident being outside normal design and operating provisions presents special resource, management, instrumentation and control arrangements, in particular when multiple plants are involved. Furthermore, the IAEA found that guidance regarding multi unit sites with respect to external hazards was lacking. Therefore many of the lessons learned and conclusions deal specifically with common-cause failure for multiple unit sites - common to all three areas (external hazards, severe accidents and emergency preparedness). The IAEA review identified a '*lack of defence in depth*' and further a '*lack of consideration for diversity*' for the design of ultimate heat sinks. The USNRC has issued one high-level report and one detailed report on the lessons learned from the Fukushima event [6]. The latter made sweeping recommendations on design in the US, with a focus on external events and mitigation provisions.

The CNSC issued a Fukushima Final Report [7] and Action Plan [8] that identifies thirteen recommendations for (i) strengthening reactor defence in depth, (ii) enhancing emergency response and (iii) improving regulatory framework and process. These recommendations are applicable to current operating stations and new build designs. The CNSC Fukushima task team identifies '*extended defence in depth*' to be applicable to new build designs. Post-Fukushima, the Canadian Nuclear Safety Commission made a presentation to the Convention on Nuclear Safety on Canada's response, including re- affirming the CANDU two-group philosophy against common mode failure, and the presence of numerous, diverse heat sinks to manage severe accident conditions. Also noted was that Candu Energy (formerly AECL) would review lessons learned, and incorporate any necessary improvements into new build design.

4.1 Fukushima Lessons Learned for EC6

Following the Fukushima events, all sectors of the CANDU nuclear industry, including Candu Energy Inc. (formerly AECL) high-level teams reviewed the implications on the CANDU fleet of reactors. A specific task team was also set up to review the EC6 design. As the Fukushima event was a beyond design basis event, the focus of the latter review was on both the definition of design basis external events and on the capability of the station to handle beyond-design-basis external events.

5. EC6 Safety Enhancements

EC6 builds on the proven high performance design in the Qinshan CANDU 6 reactor, and has made generic improvements to safety, reliability and operational performance, and has incorporated extensive operational feedback, to meet the most up to date regulatory requirements and customer expectations.. As a Generation III design, the EC6 reactor builds on the defence-in-depth features of the CANDU design, and provides further improvements in accident prevention, accident mitigation, severe accident resistance and recovery, and post accident control and monitoring. [9]. The following is a summary of the assessments on how the reference EC6 design provisions addresses the different external hazards and beyond design basis events.

5.1 EC6 Provisions against External Hazards

The systems, structures and components (SSC) important to safety are designed to withstand or are protected from the effects of external events, without loss of the capability to perform their safety functions, or designed such that their response or failure is in a safe direction. External events include natural external hazards such as extreme weather conditions, earthquakes, external flooding, and man- made hazards such as aircraft crashes, hazards arising from transportation and industrial activities (e.g. explosion and release of toxic gases).

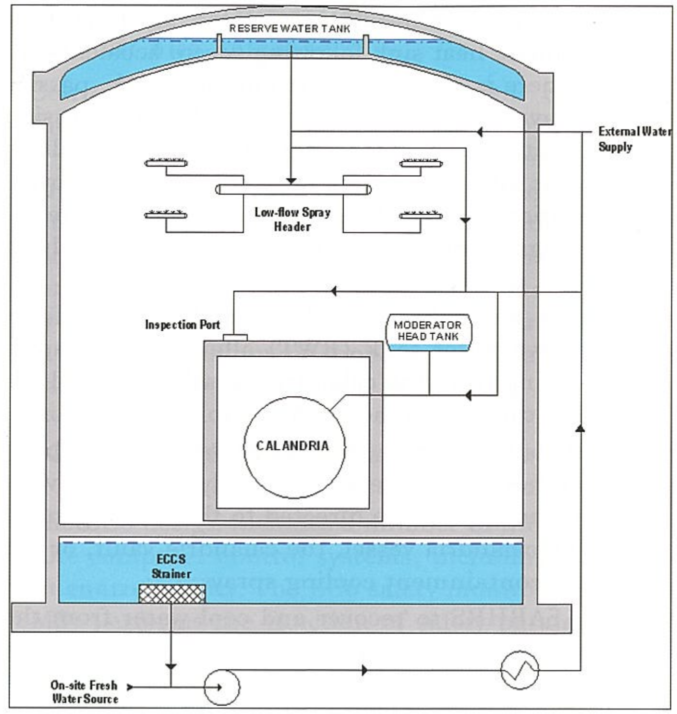
To increase the strength of EC6 against external events, some significant design enhancements have been made relative to the Qinshan reference plant:

- The reference Design Basis Earthquake (DBE) peak ground acceleration has been increased to 0.3 g.
- The main control room (MCR) and secondary control area (SCA) are seismically qualified to operate during a DBE.
- Relocation of the SCA relative to the reference design for improved security and defence against localized events.
- Relocation of the Emergency Power Supply relative to the reference design for improved security and defence against localized events.
- The service building has been design-basis-tornado (DBT) qualified. This ensures that the emergency heat removal system gravity makeup from the reserve water tank to the SGs will not be rendered inoperable following a DBT, and
- The service building concrete thickness has been increased to improve defence against malevolent acts.

5.2 EC6 Provisions Against Beyond Design Basis Accident (BDBA) Events

One of the dominant common issues apparent from the review of Fukushima lessons learned is the need to improve availability of emergency cooling water and power supplies. The EC6 design has incorporated many improvements in the area of severe accident prevention and mitigation, particularly with respect to the availability of emergency cooling and backup power capability.

The EC6 design includes a Severe Accident Recovery and Heat Removal System (SARHRS). Depending on the accident scenario/sequence, the SARHRS may be used for a Limited Core Damage Accident (LCDA) or Severe Core Damage Accident (SCDA). The system is designed to enable light- water makeup of the calandria or calandria vault inventories in order to provide decay heat removal. The system provides cooling either passively through steaming by gravity from the reserve water tank, followed by an external water source make-up (if available) ; and then actively, by recovering water from the Reactor Building sump and cooling it using the SARHRS heat exchanger prior to recirculation. Provisions are also made for containment pressure suppression and fission product washout via a containment cooling spray. The spray



Severe Accident Recovery and Heat Removal System Diagram

function can be performed simultaneously with either calandria vessel or calandria vault makeup (depending on the circumstances of the accident) for steam condensation in order to maintain the containment pressure within allowable limits.

The major equipment for SARHRS include a unit specific containment heat removal pump and heat exchanger, and a cooling water pump for supplying the secondary side of the heat exchangers. To ensure that water makeup flow can be delivered under different plant conditions, secondary flow paths are provided which do not require any valves inside the reactor building to be opened. These valves and pumps are powered by a dedicated power supply, which is comprised of a seismically qualified, dedicated diesel generator and electrical distribution system, designed to be shared between two EC6 units. Therefore all necessary operations required for a seismic event are seismically qualified and the necessary equipment is located outside the reactor building for accessibility.

5.3 EC6 Heat Sink Capability

The design includes numerous flow paths to the ultimate heat sink (local body of water and/or atmosphere) for normal operation, design basis events, and beyond design basis accidents. EC6 has numerous heat transfer paths to remove decay heat from the fuel to the ultimate heat sink via the primary and/or secondary sides during normal operation and following design basis accidents. Additionally, the SARHRS system is a completely independent means of transferring decay heat to the ultimate heat sink following severe accidents. In the EC6 there is always at least one heat sink, passive or active, available at any stage of accident progression that will halt or delay progression of the accident, allowing time for other mitigating measures to be employed. For mitigation of beyond design basis accidents, the following design features are capable of delaying or halting progression of the event:

- Provision for make-up to the calandria vessel from the reserve water tank (RWT) allows heat removal by steaming from the calandria vessel, to extend the available time for an active heat sink to be restored.
- RWT inventory can be replenished by SARHRS drawing water from on-site water supply (lake or river). RWT inventory can be directed to the steam generators, the calandria vessel, the calandria vault, or the low-flow containment cooling sprays.
- Use of SARHRS to recover and cool water from the RB floor and restore it to the calandria vessel or the calandria vault. Cooling for the SARHRS heat exchanger is by a dedicated SARHRS cooling water pump, using inventory from the on-site water supply (such as water from lake intake or from sea intake).
- Engineered connections to allow calandria vault and vessel make-up from an external water supply, in the unlikely event that all of the above water sources are exhausted or unavailable.

5.4 EC6 Provisions for Station Blackout Coping Capability

The dominant initiator of the Fukushima event was the extended loss of all AC power that resulted in emergency heat removal systems being unable to prevent fuel damage at three of the six units. By design, the EC6 has incorporated improvements that help to prevent and mitigate consequences from a station black out event (SBO).

Station blackout involves a loss of off-site power concurrent with a turbine trip and failure of the on- site safety alternating current (AC) power system (both Class III standby diesel generators and emergency power). It should be noted that each unit has two Class III standby generators, capable of accepting loads within three and a half minutes, for a mission time of seven days. In addition, each unit is provided with a dedicated emergency power supply (EPS) system, discussed below. A separated and seismically qualified dedicated power supply is provided to support SARHRS. In the case of a seismic event or station blackout resulting from a seismic event, a seismically qualified uninterruptible power supply (UPS) is provided to supply loads required for heat sink.

Key EC6 mitigative design features for this event are:

- Gravity injection of water to steam generators (SGs) from the RWT.
- Batteries to ensure at least 24 hours of capability to support make-up from the RWT to the SGs.
- SARHRS is capable of refilling the RWT with water taken from the on-site cooling water source (lake or river). Alternative supply for refilling of RWT is possible via engineered connections.

In the extreme event that all engineered features are unavailable, the inventories in the steam generators, the calandria vessel, and the calandria vault will slow event progression. At any stage of the event, off-site water supplies may be established (using provided connections) to halt event progression.

Following a SBO event, if the motorized valves from the RWT to the SGs do not open automatically, the operator will have approximately 2.9 hours from the start of the event before heat-up of the fuel. With make-up from the RWT to the steam generators available, there is sufficient capacity to keep the fuel cool for over three (3) days.

After 24 hours, extended coping strategies are in place to provide core and SFB cooling, and HTS and containment integrity. These strategies rely on portable equipment which is safely stored onsite and protected from external events. This extended coping time will be sufficient for use of pre-planned and pre-staged offsite resources for maintaining core and SFB cooling, and HTS and containment integrity.

5.5 Emergency Power Supply System

Each unit is provided with a dedicated system comprising emergency power generators (EPGs), batteries as the uninterruptible power supply (UPS), and equipment distributing power from those sources. EPS is seismically qualified. EPS starts up automatically when required and is an alternate power source to selected safety and systems important to safety such as ECC, containment cooling, and emergency heat removal system. The EPS generator location has been reviewed in terms of grouping and separation from the other diesel generators and their margins to potential flooding scenarios.

In case of a seismic event or station blackout (SBO) resulting from a seismic event, the seismically qualified UPS supply loads required for heat sink. At the onset of a Class III failure, the EPS batteries are in a fully-charged state capable of supporting the EPS loads for up to 24 hours for severe accident scenarios (motorized valves for water supply from reserve water tanks).

5.6 Maintaining Cooling to Spent Fuel Bay

The Fukushima accident identified the need to ensure cooling of spent fuel pools in case of loss of all power. Spent fuel bays in CANDU reactors are located outside the reactor buildings at grade elevation to prevent interaction between events in containment and events in the SFB. They are not elevated. Provisions are in place for the EC6 design to ensure monitoring and cooling of spent fuel bay by additional make-up.

The spent fuel bay cooling and purification system provides cooling of the water in the spent fuel, reception and discharge bays, to dissipate the decay heat from the irradiated fuel during normal operation. This is done by circulating the elevated temperature water from the spent fuel bays through a heat exchanger and then returning the water to the bays. During normal operation, the system is designed to remove decay heat that is released from irradiated fuel in the spent fuel bays and maintain the bay water temperature within acceptable limits.

5.7 EC6 Provisions for Severe Accident Management and Mitigation

The Fukushima lessons learned have identified the importance of proper planning and preparatory measures for severe accident management. In particular, the Fukushima lessons learned have highlighted the importance of the role of a robust containment design, hydrogen mitigation provisions and adequate provisions for control and monitoring during accident conditions.

One of the pertinent improvements for the EC6 design is an improved containment structure, which provides additional margin in maintaining containment integrity following severe accident events and provides additional time for emergency response. The EC6 containment structure provides an environmental boundary, biological shielding, and a pressure boundary in the event of an accident.

The containment includes design enhancements that have been made for the EC6:

- The design pressure of the reactor building has been increased from operating CANDU plants
- Increased thickness of concrete.
- Increased level of seismic qualification.
- Addition of the steel liner along the entire inside surface of the containment structure.
- A protective layer of refractory concrete is provided on top of the calandria vault floor. It delays molten core interaction with structural concrete, slows down the rate of production of non-condensable gasses, and hence reduces the rate of containment pressurization.
- Capability to prevent containment failure due to over pressurization during severe accidents through core heat removal and containment spray cooling provided by SARHRS.

5.7.1 Hydrogen Mitigation to Minimize Off-Site Releases

Containment atmospheric hydrogen control is achieved by passive autocatalytic recombiners (PARS) and active igniters that limit the concentration of hydrogen in the reactor building atmosphere to below the threshold limit at which rapid deflagration or detonation could occur. In the event of severe accidents where the quantity and rate of production of hydrogen may be high, active igniters placed at strategic locations in the containment supplement the action of the passive recombiners.

5.7.2 Improved Safety Parameters Monitoring Functions Following a Severe Accident

The EC6 design includes a number of improvements to the computer control systems, including post accident controllability. The EC6 safety monitoring system (SMS) performs the function of safety parameter display system that provides safety system monitoring during normal plant operation and post-accident monitoring functions following an event. This is achieved by providing information on the critical safety functions for supporting the proper operation of the reactor including detection and diagnosis of malfunctions to allow mitigation of these conditions.

Within the SMS envelope for the EC6 design are the critical parameters and the parameters required for post accident monitoring. Post accident monitoring (PAM) including monitoring of severe accidents, provides plant operators with information to monitor DBA and/or BDBA conditions in the plant and to assist the operators in making decisions regarding other systems that shutdown, cool and contain the unit in a safe state.

5.7 Further Assessment of Fukushima Lessons Learned for EC6

The accident itself, as well as international and industry-wide preliminary lessons learned from the event, was analyzed in order to identify any gaps or opportunities for improvement in the EC6 design. The generic plant safety topic areas arising from Fukushima that vendors and operators are addressing worldwide include:

- Robustness to design basis and beyond design basis earthquakes and floods
- Fire protection, including fires in conjunction with seismic or flood events
- Response to prolonged station blackout
- Ability to restore and maintain cooling to a damaged core

- Management of hydrogen generation/release
- Supply of services and protection to on-site staff managing a severe accident
- Robustness of spent fuel management systems (wet and dry storage).

Many of the design features incorporated in the reference EC6 described in the section above, which were originally enhanced to meet the safety requirements stated in latest CNSC requirements in RD-

337, address the key themes emerging as lessons learned from the Fukushima event, in particular protection against severe external events such as i) seismic, ii) flooding and iii) station blackout (SBO) mitigation capability. The evaluation completed has identified areas for further assessment of event sequences from severe external events, which are characterized by consequential loss of power and/or loss of heat sink and hence present the most challenge. Additional enhancement of accident response is being considered in the current EC6 Development project for the management of heat sinks and severe accident management. These include the use of portable equipment, such as engineered connections

for portable water make-up and portable diesel generator, mulit-unit post accident considerations, and enhancements to spent fuel bay and for post accident monitoring. The application of the Fukushima lessons learned will further strengthen the lines of defence.

6. Conclusion

The Enhanced CANDU 6 (EC6) is the new Generation III CANDU reactor design that meets the most up to date regulatory requirements and customer expectations. EC6 builds on the proven high performance design such as the Qinshan CANDU 6 reactor, and has made improvements to safety, operational performance, and has incorporated extensive operational feedback meeting Generation III requirements. The Fukushima Daiichi March 11, 2011 event has demonstrated the importance of defence-in-depth considerations for beyond-design basis events, including severe core damage accidents. The EC6 design is based on the defence-in-depth principles and provides further design features that address the lessons learned from Fukushima. The CANDU design, including EC6, has an appropriate combination of inherent, passive safety characteristics, and engineered and administrative safety features. These characteristics provide the proper balance to effectively mitigate and prevent severe accident progressions. The design has been developed over many years and consists of attributes that i) prevent accidents, ii) if they occur, stop them and limit the consequences; iii) if they progress to core damage, provide protection and mitigate severe accident scenarios. The application of the Fukushima lessons learned will further strengthen the lines of defence for beyond design basis events.

7. References

[1] "Defence in Depth in Nuclear Safety", INSAG 10-1996, IAEA, June 1996.

[2] CFD Model of CANDU Calandria Vessel Retention During Severe Accidents, by F. Song, B.Lekakh and K. Hau, The 14th International Topical Meeting on Nuclear Reactor Thermal Hydraulics, Toronto, Ontario, Canada, 2011 September 25-29.

[3] Spent Fuel Response after A Postulated Loss of Spent Fuel Bay Cooling Accident, by H.Z. Fan, R. Aboud, E. Choy, W. Zhu, and H. Liu, 33rd Annual Conference of the Canadian Nuclear Society, Saskatoon, Saskatchewan, 2012 June 10 – 13.

[4] Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety – "The Accident at TEPCO's Fukushima Nuclear Power Stations", Nuclear Emergency Response Headquarters; Government of Japan, June 2011, and Additional Report in September 2011.

[5] IAEA International Fact Finding Expert Mission Of The Fukushima Dai-Ichi NPP Accident Following The Great East Japan Earthquake And Tsunami" Tokyo, Fukushima Dai-ichi NPP, Fukushima Dai-ni NPP and Tokai Dai-ni NPP, Japan 24 May – 2 June 2011, June 16, 2011.

[6] Charles Miller et al., "Recommendations for Enhancing Reactor Safety in the 21st Century - The Near-Term Task Force Review of Insights from the Fukushima Dai-Ichi Accident", US Nuclear Regulatory Commission, July 12, 2011

[7] CNSC Fukushima Task Force Report, INFO-0824, October 2011.

[8] CNSC Staff Action Plan on the CSNC Fukushima Task Force Recommendations, INFO-0828, March 2012.

[9] The EC6 – An Enhanced Mid-Sized Reactor with Fuel cycle Applications by M. Soulard, S. Yu, J. Hopwood and I. Hastings, International Conference on Future of HWRs, Ottawa, Ontario, Canada, October 2-5, 2011.


SIMULATIONS AS REAL AS
THE NEED FOR SAFETY

GENERAL news

(Selected by Fred Boyd from open sources)

Labour dispute at Candu Energy ends

On September 8, 2012, both Candu Energy Inc. and the Society of Professional Engineers and Associates, which represents most of the scientific staff, announced that they had signed a revised Memorandum of Agreement.

This modified MoA removed a note in the one which members approved by a vote August 24 which indicated the Society's intention to litigate the site seniority issue. However, Candu Energy objected to that clause and locked out members.

In the revised MoA, the issue of "site seniority" has been resolved with the agreement of the parties on new language defining Project Hires and Project Sites. Both parties have agreed to withdraw all outstanding legal actions currently before the Canadian Industrial Relations Board while jointly requesting mediation support from Federal Mediation and Conciliation Services for outstanding grievances.

Another element of the MoA is the agreement between the parties to participate in facilitated relationship-building / re-building activities in an effort to ensure an effective working relationship going forward.

The company commented that "a fair and competitive new Collective Agreement for our employees represented by SPEA-SE is an important milestone for Candu and signifies stability for the company, our employees and the CANDU nuclear industry"

The SPEA executive questioned "whether this agreement helps to give ...members sufficient incentive to remain with Candu Energy, only time will tell".

Bruce A update

After four years of extensive rebuilding of units 1 and 2 of the Bruce A station, as of September 5, both units were still sitting with their reactors critical but held to less than 1per cent of full power due to non-nuclear problems.

Bruce Power received approval from the Canadian Nuclear Safety Commission to start Unit 2 on March 15, 2012 and Unit 1 on July 20.

Back in May, reactor power on Unit 2 had been raised and was producing steam. Just before intended synchronization with the grid a problem was identified within the generator, which had been upgraded as part of the refurbishment project. Inspections revealed that extensive repairs would be required. Bruce Power is still in negotiations with Siemans Canada, original suppliers of the generator which had conducted the upgrading.

Bruce Power turned its attention to Unit 1. On August 24, 2012, when commissioning an electrical system a small electrical fire erupted in a piece of electrical equipment. No injuries occurred but two workers were sent to hospital for examination after smoke inhalation. As of September 5 investigation of the root cause and repairs was underway.

An earlier view of the Bruce A control room.

Cameco agrees to buy uranium project in Western Australia

Cameco has announced that it has agreed to buy the Yeelirrie uranium project in Western Australia from BHP Billiton for $430 million.

The shallow and extensive Yeelirrie deposit - amenable to open pit mining techniques - was discovered by Western Mining Corporation in 1972. Although the project gained environmental approval from the state and federal governments around 1980, subsequent changes in uranium mining policy stalled the project. In 2005, ownership of the deposit - some 650 km northeast of Perth and about 750 km south of Cameco's Kintyre exploration project - transferred to BHP Billiton.

Based on a historic estimate prepared for BHP Billiton in June by an international mining consulting firm, Yeelirrie has measured and indicated resources of some 139 million pounds U_3O_8 (53,465 tU), with an average ore grade of about 0.13% U3O8 and inferred resources of around 5 million pounds (1923 tU) at 0.10% U3O8. While the historic resource estimate is compliant with Australia's JORC standard, it has not yet been classified according to the Canadian National Instrument 43-101 (NI 43-101) standard.

Cameco expects the transaction - which is subject to approval from the Western Australian government and the Australian Foreign Investment Review Board - to close by the end of 2012. On completion of the deal, the company will be liable to pay $22 million in stamp tax duty to the government of Western Australia.

AECL holds public Open House for the first time in over a decade

Aerial view of part of the Chalk River Laboratories.

For the first time since 2000, Atomic Energy of Canada Limited (AECL) held a public open house at the Chalk River Laboratories on Saturday, August 11, 2012. Over 2,000 visitors attended.

The event gave the local community an opportunity to learn more about the laboratories and some of its unique science facilities.

With over 50 displays and activities, there was something for everyone. Children spent time at the "Kids in Science" demonstration by Science North where they took part in hands on science experiments.

Bob Walker, President & CEO at AECL commented that the event took six months of planning. "In the end I think we showcased some of the important science and technology work that takes place here at the Chalk River Laboratories" he added.

Last held in the summer of 2000, the Open House was intended to provide the local community with a glimpse into some of the different programs and services that AECL undertakes on behalf of Canadians. After a brief orientation presentation, visitors were able to participate in walking tours of laboratories and facilities managed by different AECL departments, including the Mechanical Equipment Development, Inspection, Monitoring & Dynamics, Fluid Sealing Technologies and the Machine Shop.

Candu Energy Signs Agreement with China

In early August 2012 Candu Energy Inc. announced that it had signed an expanded agreement with China National Nuclear Corporation's subsidiary companies, Third Qinshan Nuclear Power Company (TQNPC), China North Nuclear Fuel Corporation (CNNFC) and Nuclear Power Institute of China (NPIC) to continue co-operation in the development of recycled uranium and thorium as alternative fuels for new CANDU reactors.

With a 24-month duration, the agreement is expected to result in a detailed conceptual design of the Advanced Fuel CANDU Reactor (AFCR). The AFCR is a further evolution of the successful CANDU 6 and Generation III Enhanced CANDU 6, which is optimized for use of recycled uranium and thorium fuel.

The agreement follows the successful demonstration irradiation of recycled uranium fuel bundles in operating CANDU reactors at the Qinshan site. The tests demonstrated the feasibility of using natural uranium equivalent (NUE) fuel, composed of recycled uranium and depleted uranium in CANDU reactors. The parties are now working on a project to convert the Qinshan CANDU reactor units to full core use of NUE fuel by 2014.

View of Qinshan site.

CNSC invites comment on Safety Culture

The CNSC has released for public consultation Discussion Paper DIS-12-07, *Safety Culture for Nuclear Licensees.*

Safety culture is a relatively new concept, but has grown in importance for the nuclear industry worldwide. Canadian licensees are becoming increasingly aware of safety culture and applying it internally, but there still exists an uneven understanding and application of the concept. The approach licensees use to do a self-assessment of their own safety culture also varies widely.

Discussion papers are used to solicit comments from the public, licensees and interested organizations early in the regulatory process.

This discussion paper presents the CNSC's proposed approach for regulating safety culture in the Canadian nuclear industry, highlighting its importance, as well as what has been done both internationally and in Canada to promote it.

The CNSC is seeking comments from licensees, stakeholders and the public on the proposals in this discussion paper, including comments about the safety culture self-assessment guidelines presented in Appendix C. Feedback received will support the CNSC's ongoing efforts to provide greater clarity to both industry and the public on the CNSC's proposed approach and expectations related to safety culture.

Comments submitted, including names and affiliations, are intended to be made public.

Comment period: September 5, 2012 to January 4, 2013

How to participate: Please submit your comments:

- Online, using the electronic comment form
- Email: consultation@cnsc-ccsn.gc.ca
- Mail: Canadian Nuclear Safety Commission
  P.O. Box 1046, Station B
  280 Slater Street
  Ottawa, Ontario, Canada K1P 5S9

CNSC Issues a Site Preparation Licence for new build at Darlington

On August 17, 2012, the Joint Review Panel (JRP) of the Canadian Nuclear Safety Commission (CNSC) announced its decision to issue a *Nuclear Power Reactor Site Preparation Licence* to Ontario Power Generation Inc. (OPG) for its new nuclear power plant project at the Darlington nuclear site for a period of 10 years. The licence will be valid from August 17, 2012 to August 17, 2022.

In making its decision, the JRP considered information presented at the 17-day public hearing held March 21 to April 8, 2011, during which it received and considered submissions from OPG and 264 intervenors, as well as 14 government departments, including the CNSC.

The JRP was established in 2009 to consider the environmental assessment and the licence application to prepare a site for the proposed Darlington project. In August 2011, the JRP submitted its environmental assessment report to the Government of Canada, concluding that the project was not likely to cause significant adverse environmental effects, taking into consideration the implementation of proposed mitigation measures. In May 2012, the Government agreed with the JRP's recommendation, and authorized the project to proceed to licensing to prepare a site. This marked the end of the first step in the multiphase CNSC licensing process that is required for any new nuclear power project in Canada.

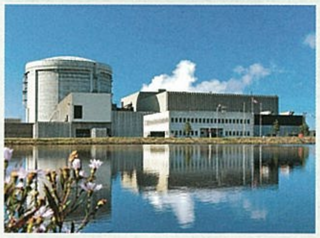
The JRP has directed OPG and CNSC staff to prepare mid-term reports on the project. All reports will be presented in a public forum.

The next step in the regulatory process will be the CNSC licensing decision phase to construct a nuclear power plant, once OPG submits its application.

A Record of Proceedings, including Reasons for Decision, and transcripts of the hearing are available on the CNSC Web site at nuclearsafety.gc.ca, or by contacting the CNSC.

Existing Darlington site.

Point Lepreau approved to increase power



On August 28, 2012, the Canadian Nuclear Safety Commission (CNSC) announced its decision to allow the Point Lepreau Generating Station to increase reactor power above 0.1% of full power.

NB Power will require one further CNSC regulatory approval prior to increasing reactor power above 35%.

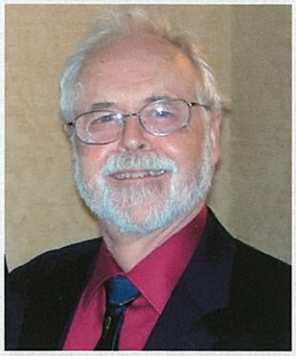
At this stage, the Station will not produce electricity. Station staff will continue to increase reactor power in order to perform several safety tests. The CNSC will continue to provide oversight in the form of on-site inspections and technical reviews of the remaining testing and commissioning activities.

Tests and verifications to ensure the reactor components and plant systems operate safely and reliably will continue. In parallel, the reactor power will be gradually increased to pre-determined levels.

Prior to reaching the final approval to proceed to full power, station staff will perform a planned shutdown to remove specialized equipment used to start up reactors with new fuel as part of the testing and commissioning process. During this shutdown, any adjustments or maintenance that may arise during turbine run up and testing activities will also be completed before restarting the reactor to continue the commissioning process system.

NB Power remains on track to restart the Station and start generating electricity in the fall of 2012.

Message from the President



As I write this brief message humid and warmer weather is embracing Bruce County and Ontario. Ric Fluke tells me that the last time that a "Message from the President" appeared it was authored from Bruce County by then President Eric Williams.

The first two months of my Presidency have been busy between representing the CNS at the American Nuclear Society's summer meeting (Chicago) and a visit to NPD with no less than the original electricity from nuclear power protagonist and first Station Manager, Dr. Lorne McConnell. We even entered the boiler room, somewhere I had last entered in 1979 when I was part of the boiler chemical cleaning team.

Two committees to be chaired by the President were authorized by Council . The first Committee was to examine CNS Program expenditures and the second was to examine the CNS by-laws. The urgency for the former committee has abated; however, the exercise of weekly teleconferences was not wasted effort. The latter committee is meeting weekly by teleconference and making excellent progress. The stimulus for this committee is new legislation pertinent to non-profit organizations. The plan is to have the by-laws reworked, and undergone legal review, by early 2013 such that all CNS members will have ample time to review the new by-laws prior to the 2013 Annual General Meeting.

There is excellent news from Darlington with progress on new nuclear new build. In Bruce County eight reactors are once again critical and commissioning progresses on Bruce Units 1 & 2.

AECL has produced the first edition of their on-line journal, "AECL Nuclear review", which is an excellent read.

Returning to the weather, I believe that the heat and lack of water (the latter being my fault) led to my scarlet runner beans (pole beans) having lots of flowers but no beans. I have corrected the latter and bean pods are happily being produced. The only issue is that I have to climb a ladder to reach the upper level at close to six feet above my head! Why do I tell you this – because without the radiation from the fusion reactor in the sky my beans (and most other plants) would not be growing!

John Roberts

Richard Osborne receives Sievert Award

Note: This item was unfortunately missed from the June issue of the CNS bulletin.

Richard Osborne, founder and past President of Canadian Radiation Protection Association and a long-time member of the Canadian Nuclear Society, has been awarded the prestigious Sievert Award for 2012 for his contributions to radiation protection by the International Radiation Protection Association (IRPA). The award was presented to Dr. Osborne at the IRPA conference held in Glasgow, Scotland in May 2012.

On receiving the award, Dr. Osborne presented a lecture on "The Story of Tritium", the subject of much of his research over the years.

He received his Ph.D. from London University in 1962. A year later he joined the Chalk River Laboratories of Atomic energy of Canada Limited as a research officer in the Health Physics Branch. Over the years he assumed greater responsibilities and in 1989 was appointed Director of the Health & Environment Division at CRL. Until his retirement in 1998 he was responsible for all of AECL's programs in health sciences.

Internationally, he served on Committee 4 of the International Commission on Radiological Protection and on several Advisory groups of the Nuclear Energy Agency of the OECD, the NCRP of the USA, and the IAEA. In Canada he was a member of the Advisory Committee on Radiological protection of the CNSC.

Since retirement Dr. Osborne has been active as a consultant through his company Ranasara Consultants Inc.

Look to the Stars, What an Exciting CNS Event!

By BLAIR BROMELEY

Summerfest rocked the town of Deep River from August 2nd to 5th. The Canadian Nuclear Society Chalk River Branch brought the joys of science and astronomy to life at this anticipated event by sponsoring the Science North Travelling Planetarium. Over 1200 space travelers came out to see the different shows available. The event was wildly popular and a well-received part of the festival, stimulating the participants' interest in science and astronomy.

There were three different shows that were played at the event. In the first show, the audience was introduced to the stars and constellations that can be identified if one lays back and admires the summer night sky. The second show transported the viewer through space, visiting various planets and moons in our Solar system, while looking at some of the "craziest weathers", from dust storms on Mars, to the methane rain on Titan and the diamond showers on Neptune and Uranus. The last show highlighted the August 5th Mars landing, the reasons why Pluto is no longer a planet and the many vehicles that we have sent out into space.

All in all, it was a remarkable voyage through space, and the enthusiastic visitors were willing to wait for over an hour to be part of it. It would not have been possible without the support of the Canadian Nuclear Society, AECL and the Summerfest Committee. The Chalk River Branch would like to thank the Canadian Nuclear Society for supporting this initiative, AECL for use of their facility and services and the Summerfest Committee for helping coordinate the event with Science North. A big thank you is also due to the Science North crew (Bryen McGuire and Gabriel Grenier) for their excellent presentations. Lastly, we would like to thank all our volunteers, without whom the entire event would not have been possible.

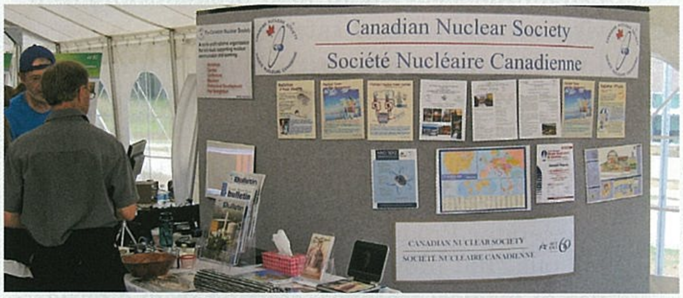
CNS at AECL Open House

The Canadian Nuclear Society was well represented at the first Open House of the Chalk River Laboratories held by Atomic Energy of Canada Limited in over a decade. The event, held on Saturday, August 11, 2012 drew about 2,000 visitors.

Two well-known members of the CNS Chalk River Branch gave presentations. Jeremy Whitlock spoke on the history of AECL, presented a short story of the Ottawa River heritage and gave his Nuclear 101 lecture, Morgan Brown reported on the Fukushima event of March 2011 and the Canadian Nuclear industry.

Along with the presentations by various AECL divisions and branches on their programs, the CNS had a booth, organized by the Chalk River Branch. This was organized by the Branch but Ben Rouben and Nick Sion came from Toronto and Colin Hunt from Ottawa to assist and present information about the Society at large. Nuclear Canada Yearbooks and Bulletins were handed out to those dropping by the booth. The Rutherford Documentary was played in the background and Bryan White performed Geiger counter demonstrations to a large crowd throughout the day. The Branch representatives provided information about the activities that the Chalk River Branch is undertaking. Visitors were invited to submit their names for a draw for five *Canada Enters the Nuclear Age books.*

A large number of people (both children and adults) visited the CNS booth, asking questions about the nuclear industry, watching Bryan's demonstrations and finding out who the CNS is and what it does.



CNS booth at AECL Open House.

Bryan White demonstrated radiation measurement at AECL Open House.

News from Branches

ALBERTA – Duane Pendergast

Duane Bratt has published another book. This one is titled ***"Canada, the Provinces, and the Global Nuclear Revival":* Advocacy Coalitions in Action.** The publisher notes it is "A state-of-the- art exploration of Canada's place in the rapidly shifting world of electricity....."

http://mqup.mcgill.ca/book.php?bookid=2916

CHALK RIVER – Ruxandra Dranga

Speakers:

- DRSA talks in July / August:
  - ◊ July 10: Jeremy Whitlock – Splitting Atoms Canadian Style. Basic presentation of nuclear energy, history of the industry, answers to common questions, etc. This presentation was opened only to DRSA students as it took place at their housing site.
  - ◊ July 12: Metin Yetisir (AECL) – Mechanical Aspects of the Canadian GEN-IV Supercritical Water Cooled Reactor Design. Metin discussed the current design and the design goals for the Canadian SCWR concept.
  - ◊ July 19: Ruth Brinston (Biovive Consulting Inc.) – A Global Perspective on Food Irradiation. In her talk, Ruth discussed the use of ionizing radiation around the world to extend the shelf life of food products and as a vital process in food safety.
  - ◊ July 26: John Katsaras (ORNL) – Rutherford and his Laboratory. John gave an interesting presentation of Rutherford's history and the discoveries made in his Lab.
  - ◊ August 2: Bill Diamond (AECL Emeritus) – Accelerator Production of Medical Isotopes. In his talk, Bill provided a broad overview of the use of medical isotopes, starting from a basic review of the nuclear physics of isotope production and the use of the isotope for medical imaging. He also described the use of accelerators to produce several of the important isotopes.
- Future talks:
  - ◊ PEO / CNS joined workshop: "Introduction to Transformational Leadership for Excellence" – September 12, 2012

Education and Outreach:

- July 25: Bryan White presented a version of the Ionising Radiation Workshop to the DRSA students and tutors at the DRSA Residence cafeteria. Approximately 23 students were introduced to aspects of the science. They had the opportunity to make hands-on observations with Naturally Occurring Radioactive Materials using the six Geiger workstations.
- August 3-5: The wonders of space and some of the science behind them were brought to Deep River during the Summerfest events by means of the Science North Planetarium sponsored by the CNS – Chalk River Branch. Due to limited space, only 1212 people attended this event during the three days (60% adults, 40% children between age 4 & 16). Before and during the shows, a presentation was played on a separate projector introducing and promoting the CNS to those waiting for the Planetarium. Also, the volunteers have been promoting the CNS and the CNS Chalk River Branch to the public.

Acknowledgements:

- We wish to acknowledge the invaluable help of the following volunteers during the Summerfest; Bruce Wilkin, Bryan White, Geoff Edwards, Blair Bromley, Tracy Pearce, Allen Muirhead, Ed Nicholson, JingJing Wang, Sarah Dunford, Susan McBride, Tracy Reckzin, Candice Brown, Martin Klukas, Lorrie Gauthier, Harsha Athauda-Arachchige, Uditha Senaratne, Brian Kroes, Nicole Johnson, Duncan Barber, Toban Verdun, Ike Dimayuga, Shelley Rolland-Poruks, and Richard Moore.
- We would also like to thank the CNS Council for allowing us to sponsor this excellent event, AECL for allowing us to use their facility and services during the event, the Summerfest Organizing Committee for helping with the contract and advertising and the Science North crew (Bryen McGuire and Gabriel Grenier).

See separate article by Blair Bromeley

DARLINGTON – Jacques Plourde

There are no activities to report for the Darlington Branch since our last Council Meeting. As to our merger effort with the Pickering Branch, we are awaiting an opportunity to connect with OPG Senior Management.

OTTAWA – Mike Taylor

The Branch does not hold functions in the summer. A meeting is being arranged for November 2 at which CNS President John Roberts will speak about his deep and long experience with chemistry problems in nuclear plants, as well as current activities of the CNS Council.

PICKERING – Leon Simeon

- The Pickering Branch attended the graduation ceremonies of 2 local high schools and award three awards of excellence on behalf of the CNS – Pickering Branch.
- Scheduled a CNS presentation on September 29, 201. The topic of the presentation is "Enhanced CANDU 6 Design" by Mike Soulard.
- Scheduled a CNS presentation on November 30, 2012. The topic of the presentation is "OPG's Approach to Equipment Abandonment" by Gary Albert.
- Meeting to be arranged with senior OPG personnel to discuss the merger of the Pickering and Darlington branches.

UOIT – Terry Price

Since last report, the CNS at UOIT held two events: the McMaster reactor tour, and the hosting of Leah Shurparski who came to speak about the CRPA.

Trip to the McMaster Reactor and Tandem Accelerator Laboratory

On the July 20, 2012, the UOIT branch of the Canadian Nuclear Society took a field trip to see the Nuclear Reactor and Tandem Accelerator Laboratory at McMaster University in Hamilton. This trip had been in the making for approximately 6 months, and was executed by the UOIT Branch executive.

Fifty people were in attendance on the trip including graduate students, undergraduate students, and co-op students at OPG who had been excused from work for the day to attend the trip. All 50 spots were filled up within 3 days of our announcement, and many people had to be unfortunately turned away. We provided transportation to and from UOIT via a rented bus. These 50 students were broken into 5 tour groups which could easily be handled by the staff at McMaster.

The trip itself lasted approximately 8 hours from the time we left UOIT to the time we returned. During the tour, groups were cycled through the Tandem Accelerator Laboratory, the Reactor and a lunch period before they were once again all gathered and put back on the bus.

This event was co-sponsored by the Engineering Society at UOIT who paid half the costs of the bus rental on the condition that we also allow members of that Society on the trip. The advertisement printing was sponsored by the Faculty of Energy Systems and Nuclear Science at UOIT.

This trip would not have been possible without the hard work of Niv Menon who coordinated all the registrations, and Ali Akhtar who handled affairs with the Engineering Society.

In the future we'd like to conduct more trips to other sites around UOIT so that we can further interest in nuclear science and technology.

Leah Shuparski – The CRPA: The Core of RP Careers

On the 7th of August, we hosted Leah Shuparski from the Ottawa Hospital. She spoke about her career in radiation protection and how she became involved with the CRPA. About 15 people were in attendance. She will be attempting to publish an article about the CNS at UOIT in the CRPA bulletin.

Future Plans

We are hard at work developing our program for the fall semester. We are in contact with several speakers, and we have many events planned.

Photographs of 2012 Annual Conference

The organizers of the 2012 CNS Annual Conference, held in Saskatoon, Saskatchewan, June 10-13, 2012, engaged a professional photographer, **Ron Heinrichs**, to record the event.

An extensive selection of those photographs are now posted on the CNS website at the following url.

www.cns-snc.ca/cns_galleries/gallery/cns-annual-conference-2012-2

Obituary

Bernard "Bernie" Surette

Bernard Alban "Bernie" Surette, 62, a member of the CNS Chalk River Branch, died suddenly, on Thursday, August 16, 2012, as a result of a traffic accident.

Bernie was originally from the fishing community of West Pubnico, Nova Scotia. He was educated at Ryerson Polytechnic Institute (Toronto) and came to work with Atomic Energy of Canada Limited, Chalk River Laboratories as a technologist in 1971. Bernie was eventually promoted to the position of scientist/engineer in the area of metallurgy in 1990.

Over his 42-year career at AECL-CRL, Bernie was involved numerous projects and experiments that helped lead to improvements in the performance of fuel and CANDU reactors.

Bernie's career was focused on developing nuclear fuel and understanding its behaviour. He was a recognized expert in stress-corrosion cracking (SCC) of Zircaloy fuel cladding, and worked to develop a better understanding of various SCC-related failure mechanisms in fuel bundles. He assisted in establishing new SCC testing apparatus in the research laboratories of the Royal Military College, Kingston, working with many students and professors.

For many years, Bernie supervised the Fuel Development Branch Fuel Fabrication Laboratory, where fuel elements and bundles were fabricated for testing in the NRU and ZED-2 research reactors at CRL. This work was essential to AECL's development of various advanced fuels, including Low-Void Reactivity Fuel (LVRF), MOX and higher-burnup slightly-enriched UO_2. He was heavily involved in the joint AECL/KAERI project to develop the prototype 43-element CANFLEX fuel bundle which culminated in a successful demonstration irradiation at the Point Lepreau Nuclear Generating Station. He also helped to develop a demountable CANFLEX fuel bundle for testing next-generation fuels in the NRU reactor.

Bernie was an accomplished photographer and served in that capacity for many CANDU Fuel Conferences sponsored by the CNS. His artistic talents assisted in the development of the banner for the CNS Chalk River Branch. He was a devoted family man that loved his children and grandchildren. He was people-oriented. All that came to know Bernie appreciated him for his intelligence, ingenuity and kindness. He will be greatly missed by his colleagues, friends and family.

For more information and to send personal condolences, please visit http://www.valleyfuneralhome.ca/

by Blair Bromeley

Call for Abstracts

2nd International Technical Meeting on Small Reactors

2012 November 7-9
The Albert at Bay Hotel, Ottawa, Ontario CANADA

"Celebrating NPD's 50th Anniversary"

Objective

Atomic Energy of Canada Limited (AECL) and Canadian Nuclear Society (CNS) are hosting the 2nd International Technical Meeting on Small Reactors. There is growing international interest and activity in the development of small nuclear reactor technology. This meeting will provide participants with an opportunity to share ideas and exchange information on new developments.

This Technical Meeting will cover topics of interest to designers, operators, researchers and analysts involved in the design, development and deployment of small reactors for power generation and research. A special session is planned to focus on small modular reactors (SMR) for generating electricity and process heat, particularly in small grids and remote locations. On the last day of the Technical Meeting (November 9), AECL will host a tour of the Chalk River Laboratories for all interested attendees. The tour will include the ZED-2 and NRU reactors.

Following the success of the first Technical Meeting in November 2010, which captured numerous accomplishments of low-power critical facilities and small reactors, the second Technical Meeting is dedicated to the achievements, capabilities, and future prospects of small reactors. This meeting also celebrates the 50th Anniversary of the Nuclear Power Demonstration (NPD) reactor which was the first small reactor (20 MWe) to generate electricity in Canada.

Topics of Interest

Presentations related to the following topics are of interest to this Technical Meeting:

- Safety and Licensing
- Reactor Physics (physics code validation, bias and uncertainty, benchmarking, etc.)
- Thermalhydraulics (passive safety, heat pipes, etc.)
- Advanced Fuels (new compositions, inherently safe fuels, etc.)
- Instrumentation and Control
- Research reactors and low power critical facilities
- Education and training
- Commercial SMRs for electricity generation
- Small reactors for remote locations
- Autonomous Control and Operation
- Novel Concepts

Abstract Submission

Authors should submit an extended abstract (two to three pages) with contact information, via electronic mail, to the Technical Program Chair, Shuwei Yue, (yues@aecl.ca). Extended abstracts will be published in the Conference Proceedings (CD format).

Technical Meeting Organizers

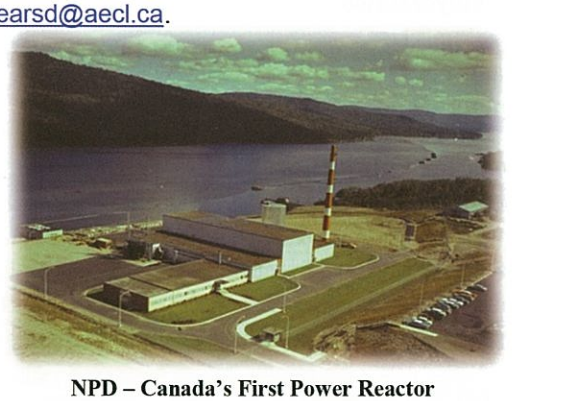
Advisory Committee.................................. Fred Boyd, CNS
Adriaan Buijs, McMaster University
Romney Duffey, DSM Associates
Iain Harry, CIC
Paul Labbé, DRDC Corporate
John McKenzie, SaskPower
Dan Meneley, UOIT
Eleodor Nichita, UOIT
John Root, CCNI
Benjamin Rouben, 12 & 1 Consulting
Marcel de Vos, CNSC
General Chair.. David Sears, AECL
Technical Program Chair......................... Shuwei Yue, AECL

Key Dates

NEW Extended abstracts deadline.........September 15, 2012
Early-Bird registration deadline .... September 15, 2012

Further Information

Additional information may be obtained by visiting http://cns-snc.ca/events/2tm/ or by contacting David Sears, General Chair, AECL, Chalk River Laboratories, Chalk River, Ontario K0J 1J0 CANADA, Tel: (613) 584-3311 ext. 44200;
Email: searsd@aecl.ca.



NPD – Canada's First Power Reactor

SaskPower Powering the future · IAEA International Atomic Energy Agency · Candu · UOIT Challenge Innovate Connect

Canadian Nuclear Society
24th Nuclear Simulation Symposium
PROGRESS IN SIMULATION TOOLS AND METHODS

PROGRESS IN SIMULATION TOOLS AND METHODS

OTTAWA 2012

2012 October 14-16
Ottawa Marriott Hotel
Ottawa, Ontario, Canada

Call for papers


Photo taken at Ottawa October 14, 2006 (© zen! / Flickr)

The Canadian Nuclear Society is organizing its 24th Nuclear Simulation Symposium. The symposium will be held in Ottawa (Ontario, Canada) from October 14 to 16, 2012.

Objective
The objective of the symposium is to provide a forum for discussion and exchange of information, results and views amongst scientists, engineers and academics working in various fields of nuclear engineering.

Topics of interest
The scope of the symposium covers all aspects of nuclear modelling and simulation, including, but not limited to:

- Reactor Physics
- Thermalhydraulics
- Safety Analysis
- Fuel and Fuel Channels
- Computer Codes and Modelling

Guidelines for full papers
The papers should present facts that are new and significant or represent a state-of-the-art review. A clear exposition of the subject should be made in approximately 10 pages. Proper references should be included for all closely related published information.

Submission procedure
Submissions of full papers, preferably in MS Word format, must be made electronically through the symposium submission site:
https://www.softconf.com/c/CNS2012Simulation/

NEW DEADLINES!
Deadline for full papers submission: .... June 30, 2012
Notification of acceptance: .... July 31, 2012
Deadline for final papers submission: ... August 31, 2012
End of early bird registration: .... August 31, 2012

Symposium registration fees (HST included)

	By August 31 / After August 31
CNS Member:	$570 / $640
Non CNS Member:	$670 / $740
CNS Retiree Member:	$200 / $240
Full-Time Student:	$200 / $240

Honorary chair
Dr. Joanne Ball
Director of the Reactor Safety Division
AECL's Chalk River Laboratories

Technical program co-chairs
Dr. Adriaan Buijs
Department of Engineering Physics
McMaster University
e-mail: buijsa@mcmaster.ca
Tel.: (905) 525-9140 ext. 24925

Geneviève Harrisson
Institut de Génie Nucléaire
École Polytechnique de Montréal
e-mail: genevieve.harrisson@polymtl.ca
Tel.: (514) 340-4711 ext. 4120

General questions regarding the symposium
CNS Office e-mail: cns-snc@on.aibn.com
Tel.: (416) 977-7620

Notes to Authors
Copyright in papers submitted to the 24th Nuclear Simulation Symposium of the Canadian Nuclear Society remains with the author and/or with his/her organization, but the CNS may freely reproduce the papers in print, electronic or other forms. The CNS retains a royalty-free right to charge fees for such material as it finds appropriate. For a paper to be presented at the symposium and to appear in the proceedings, at least one of the authors must register by the early bird date.

For all info go to SGC2012 Home, News at **www.cns-snc.ca**

7th CNS International Steam Generators to Controls Conference

Metro Toronto Convention Centre • 11-14 November 2012

SGC 2012 Focusing on

Steam Generators, Heat Exchangers & Heat Transport Architecture
Controls, Valves, Pumps & Electrical
Reactor Components & Functional Architecture

SGC 2012 is a working conference, focusing on what needs attention via:

i) **Issue-Identification and Definition** – as the critically-important Risk-Management Vehicle at the front end of Issue-Resolved Replication for New Build, Re-Build, and Ops-Support

ii) **Technical Excellence Work on Specific Issues** – including the definition of the issue being addressed, and reporting at the end as to the degree to which the issue is satisfied by the work

iii) **Configuration Overview, Chemistry and Task-Leadership Course –** Sunday PM 11 Nov

Focus

a. Everything System Architecture and Equipment Related in the Plant
b. Thermal-Hydraulic Architecture and other Essential Competencies
c. Engineering/Process Third Party Audit the Guarantors Can Take to the Bank
d. Establishing Utility Needs: Learning to Listen – Really Listen
e. Configuration-Management – Plant, Equipment and Material Requirements and Specs
f. Degradation – Modes, Root-Cause Investigations, Restoration Strategies
g. Maintainability, Operational Support and Reliability

Program Structure

Mon. 12 Nov. 2012			
Plenary	Steam Generators, Heat Exchangers & Heat Transport Architecture		
Special Technical Sessions	Steam Generators & Heat Exchangers		Poster Session
Tue. 13 Nov. 2012			
Plenary	Controls, Valves, Pumps & Electrical		
Special Technical Sessions	Controls, Valves, Pumps & Electrical	Steam Generators & Heat Exchangers	Reactor Components & Architecture
Wed. 14 Nov. 2012			
Plenary	Reactor Components & Functional Architecture		
Special Technical Sessions	Reactor Components & Fuctional Achitecture	Controls, Valves, Pumps & Electrical	

AREVA
B&W babcock & wilcox canada ltd
Candu
Curtiss Wright Flow Control Company Enertech
Lakeside
NLI
Ontario Power Generation
Rolls-Royce
SNC·LAVALIN

Some of our Sponsors and Exhibitors as of August 2012.

www.cns-snc.ca

2012

Sept. 19-21
CNS Fuel Technology Course
(location to be determined)
email: csn-snc@on.aibn.com
website: www.cns-snc.ca

Sept. 24-28
Nuclear Plant Chemistry Conference NPC 2012
Paris, France
email: jean-luc.bretelle@edf.fr

Oct. 14-16
24th Nuclear Simulation Symposium
Ottawa, Ontario
Contact: CNS Office
email: cns-snc@on.aibn.com
website: www.cns-snc.ca

Oct. 25
WiN Canada 9th Annual Conference
Kincardine, Ontario
website: www.wincanada.org

Nov. 7-9
2nd International Technical Meeting on Small Reactors
Ottawa, Ontario
email: cns-snc@on.aibn.com
website: www.cns-snc.ca

Nov. 7-9
Indian Nuclear Society 23rd Annual Conference
Mumbai, India
website: www.npcil.co.in/insac-2012

Nov. 11-14
7th International Conference on Steam Generators, Heat Exchangers, Pumps, Valves and Controls (SCG 2012)
Toronto, Ontario
Contact CNS office
email: cns-snc@on.aibn.com
website: www.cns-snc.ca

Nov. 11-14
ANS Winter Meeting and Nuclear Expo
San Diego, California
website: www.ans.org

2013

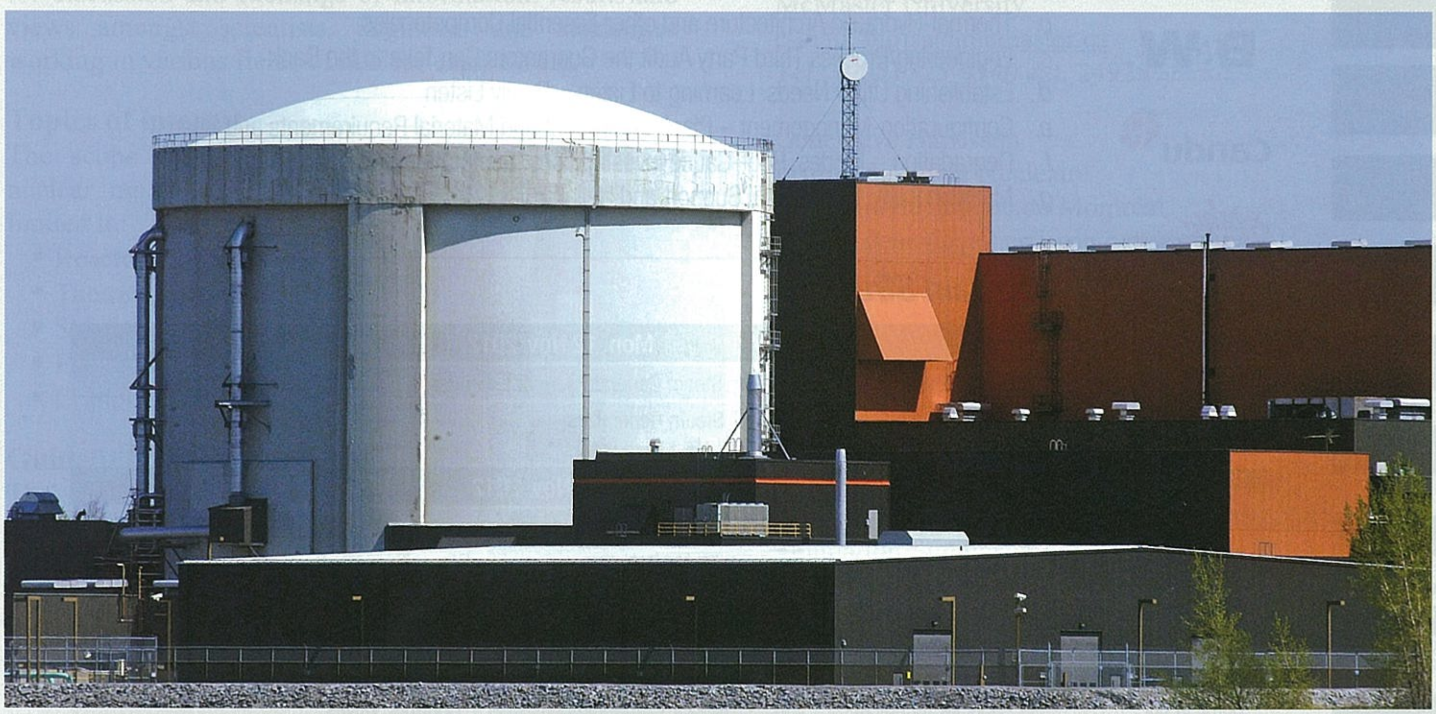
Feb. 27-Mar. 1
Canadian Nuclear Association Conference & Trade Show 2013
Ottawa, Ontario
website: www.cna.ca

May 12-17
15th International Topical Meeting on Nuclear Reactor Thermal Hydraulics (NURETH 15)
Pisa, Italy
email: dlshubring@ufl.edu

May 27-29
3rd Climate Change Technology Conference
Concordia University, Montréal, Québec
(Organized by EIC including CNS)
website: www.cctc2013.ca

June 9-12
34th Annual Canadian Nuclear Society Conference
Toronto, Ontario
email: cns-snc@on.aibn.com
website: www.cns-snc.ca

Aug. 18-23
SMiRT 22nd International Conference on Structural Mechanics in Reactor Technology
San Francisco, California
Call for Papers
website: www.smirt22.org



A view of Gentilly 2 which the newly elected government of Quebec announced September 14, 2012 would be shut down.

Arctic Aspirations

by Jeremy Whitlock

Ah, for just one time I would take the Northwest Passage
To find the hand of Franklin reaching for the Beaufort Sea
Tracing one warm line through a land so wide and savage
And make a northwest passage to the sea.
- Stan Rogers, "Northwest Passage"

GREENHITHE, ENGLAND, May 1845: Sir John Franklin's expedition to chart the Northwest Passage around North America sets sail with a crew of 24 officers and 110 men, aboard two ships: the HMS *Erebus* and HMS *Terror*. Each craft represents the latest in polar maritime technology: equipped with steam engines, they can make 4 knots (over 7 km/h) under their own power, and a combined steam-heating and distillation system keeps the crew comfortable. In addition, they are shored up with beams and iron plating, and each has a mechanism for withdrawing the iron rudder and screws into the ship for protection.

IQALUIT, NUNAVUT, May 2045: Preparations for the 2046 Winter Olympic Games are well underway in this bustling arctic metropolis. Established as a U.S. air base over a century earlier, Iqaluit later became a main link in the Distant Early Warning (DEW) radar network, and since 1999 has served as the capital of Nunavut. Although limited in growth for decades by energy infrastructure dependent upon seasonal supplies from the south, Iqaluit blossomed in the 2020s with the introduction of nuclear reactors for both heat and electricity supply, capable of running 20 years without refuelling. With a population that just topped 200,000, Iqaluit is now a vast manufacturing and trading centre, exploiting its location as the gateway to the Northwest Passage. It is also a centre for research and innovation, including one of Canada's largest nuclear engineering programs at Nunavut Arctic University (formerly Arctic College), and a vast industrial park dubbed "Nukavut" that designs and manufactures the Small Modular Reactors that have opened up the North to development in the 21st century.

DISKO BAY, GREENLAND, July 1845: The HMS *Erebus* and HMS *Terror* take on final provisions, kick out five troublemakers (reducing the total complement to 129), and prepare to sail across Baffin Bay and enter the Northwest Passage. Final letters are written home. It's been 353 years since Europeans first started seeking the Western route to the Orient, and Franklin's expedition is about to begin the process of charting the last few hundred kilometres.

CAMBRIDGE BAY, NUNAVUT, June 2035: On the tenth anniversary of the start-up of its nuclear power station, this northern metropolis on Victoria Island is both a leading cruise-ship destination and a hub of the northern mining industry. The natural beauty and resources of the Arctic are both now fully accessible through this urban centre of over 100,000 residents, and the key to unlocking this region's full potential was abundant energy. With the year-round opening of the Northwest Passage and the introduction of a suite of "micro" nuclear reactors, the gold, diamonds, iron, and other minerals are as big a bonanza here as the land's beauty.

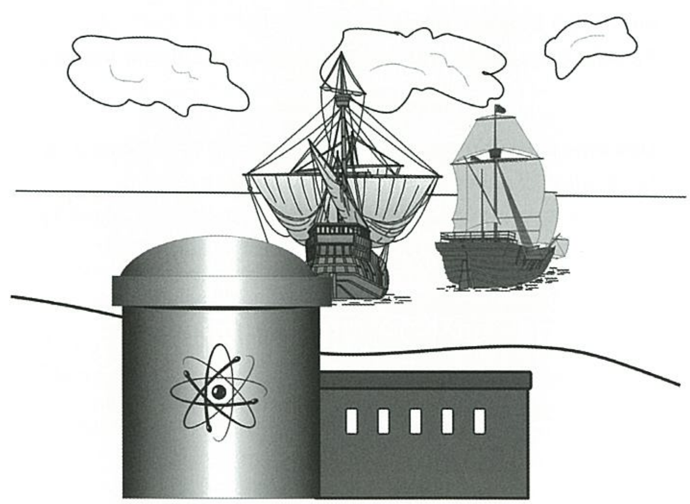
BAFFIN BAY, August 1845: The Franklin expedition is last seen as it awaits a weather window for crossing to Lancaster Sound. Modern technology will enable these bold souls to forge their way around the top of the continent in style: on board are over a thousand books in the ships' libraries, three years' worth of food supply, and even an organ.

NANISIVIK, July 2025: Canada's most northern permanent naval station is now the first Canadian military site to be powered by a dedicated nuclear reactor. The Nanisivik Naval Station is more than just a deep-water port, maintenance facility, and naval yard - it's a key piece of Canada's northern sovereignty strategy.

KING WILLIAM ISLAND, September 2012: Discoveries of more artefacts and human bones from the ill-fated Franklin expedition are found by a team led by Parks Canada; however, the big prize - the wrecks of the HMS *Erebus* and HMS *Terror* - remain elusive.

OTTAWA, November 2012: One of the themes discussed at a conference held by the Canadian Nuclear Society here on "small reactors" is the potential for nuclear technology to open up the Arctic by providing abundant, long-term, low-emission electricity and heat.

There is a growing sense that the golden age of Canada's north is about to begin.



34th Annual Conference of the Canadian Nuclear Society and 37th Annual CNS/CNA Student Conference
"NUCLEAR, the Next Generation"

Toronto Marriott Downtown Eaton Centre Hotel
Toronto, Ontario, Canada
2013 Jun 9 - 12

Call for Papers

The 34th Annual Conference of the Canadian Nuclear Society and the 37th Annual CNS/CNA Student Conference will be held at the Toronto Marriott Downtown Eaton Centre Hotel, Toronto, Ontario, Canada, 2013 Jun 9 - Jun 12.

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

Please note that this is NOT the "Call for Papers" for the Student Conference. There is a separate "Call for Students' Extended Abstracts" for the Student Conference. This "Call for Papers" is to solicit papers in Technical Sessions of the Annual Conference covering, but not limited to the following Technical Topics:

- Reactor and Radiation Physics
- Thermalhydraulics
- Reactor Safety and Licensing
- Uranium, Prospecting, Purification and Utilization
- Advanced Reactors (EC6, GEN-VI, Small Modular Reactors)
- Advanced Fuel Cycles (RU, NUE, Thorium, etc.)
- Process Systems
- Chemistry and Materials
- Instrumentation and Control
- Plant Life Extension, Refurbishment and Aging
- Operating Experience, Maintenance and Plant Transients
- Materials Issues for Existing and New Reactors
- Environment and Spent Fuel Management
- Medical Physics, Isotope Production and Applications
- Computer Code Development and Qualification
- **Special Session** on Fusion Science and Technology
- **Special Session** on Treatment of Uncertainties in ROP/NOP and LOCA Physics Calculations
- **Special Session** on Handheld Computers in Nuclear Industry

Important Dates

- **Deadline for submission of full papers: 2013 February 15**
- Notification of paper acceptance: 2013 March 31
- Deadline for submission of revised final papers: 2013 April 15

Guidelines for Full Papers

Papers should present facts that are new and significant, or represent a state-of-the-art review. They should include enough information for a clear presentation of the topic. Proper references should be made to related published information. The name(s), affiliation(s), and contact information of the author(s) should appear below the title of the paper. A short abstract of ~100 words must be placed at the beginning of the paper. A length of ~10 pages with an electronic file size of no more than 5 MB is suggested for a typical paper.

Paper Submission Procedure

Please note that ONLY FULL PAPERS are to be submitted and will be peer-reviewed for this conference (abstracts or summaries will not be accepted). Please plan accordingly as February 15, 2013 is fast approaching! Submissions of full papers should be made electronically, preferably in MS Word format, through the Annual Conference electronic submission system at:
https://www.softconf.com/d/CNS2013Technical/
To help with planning, authors should log onto the electronic submission system and input the title, author(s), and affiliation(s) of their planned paper even before making the full submission. Note that for a paper to appear in the conference Proceedings, at least one of the authors must register for the conference. Information regarding paper template and copyright can be found at the conference website: http://www.cns-snc.ca/en-ca/events/conf2013

Technical Program Chair

Dr. Eleodor Nichita
University of Ontario Institute of Technology
eleodor.nichita@uoit.ca

General inquiries regarding the Conference may be addressed to

Conference Executive Chair

Dr. Adriaan Buijs
McMaster University
buijsa@mcmaster.ca

CNS Office

Denise Rouben or Bob O'Sullivan
cns-snc@on.aibn.com
416-977-7620