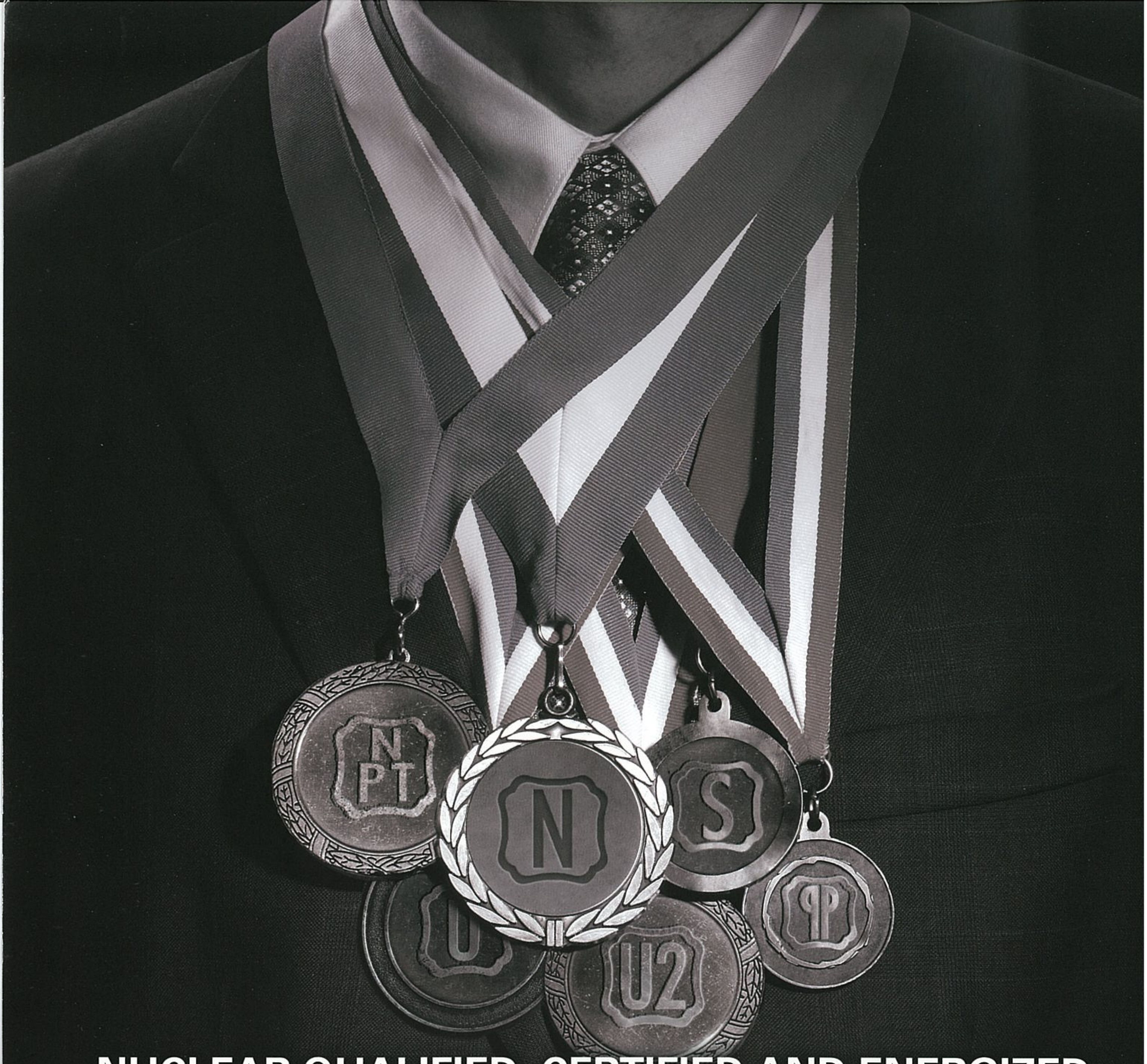
CANADIAN NUCLEAR SOCIETY

Bulletin

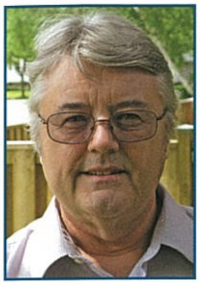
DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

SEPTEMBER 2013 SEPTEMBRE VOL. 34, NO.3

- International CANDU Fuels Conference
- Canadian Fusion Workshop
- Processing Uranium-233
- Endpoint



Where were you on August 14, 2003 at 4:11 pm?



At 4:10 pm that day I stepped out of the elevator and left the building for the parking garage. The lights were out in the stairwell, which I thought both unusual and lame. I got in my car and turned on 680News for the traffic report which I always do before hitting the highway. I heard what I thought was a live broadcast of a space shuttle lifting off. Of course it was a long time before I got to the highway with every traffic light out, but I had never seen such politeness among drivers in a crowded city before.

It was a very hot day and the power grid was straining to meet demand. What began as a brush fire somewhere in Ohio, which ionizes the air and short-circuits the power line, resulted in a cascading series of generators rejecting loads and power lines tripping, causing a massive reversal of electricity flow around Lake Erie. The grid had met its match. The great blackout of 2003 had begun.

What were you doing in December 1999? Like me you were probably stocking up with canned food, bottled water and candles and batteries. So were our friends south of the boarder, but they were also stocking up on ammunition and barbed wire. All this for fear of a massive blackout at the midnight hour of Y2K when computers would no longer be able to tell time. Meanwhile CANDU operators were preparing for such a scenario with emergency drills and simulations to ensure the nuclear reactors would remain in a safe state. So at 4:11 pm on August 14, 2003, nuclear operators did what they had been trained to do.

When a blackout occurs nuclear reactors automatically step back to 60% power. If a reactor shuts down completely and is not re-started within 20 or 30 minutes it will "poison out" and cannot start up again for two or three days. Instead, a poison out can be prevented by maintaining power and dumping steam to the condenser using the steam by-pass mode (by-passing the turbine). At Bruce and Darlington this mode of operation is virtually unlimited. Pickering, however, does not have this capability and can only dump steam to atmosphere, and will run out of demineralised water in about two hours. Nevertheless there are mandatory safety system checks that must be completed before the reactor can be put in poison-prevent mode. Bruce was able to do this within minutes for three of it reactors (only four were operating at the time) and Darlington brought one of its units back to power. There was an electrical fault in the back-up supply in one of their reactors, and the safety checks could not be completed in time for two others, so erring on safety three of the reactors were shut down manually.

Three reactors at Pickering, three at Bruce and one at Darlington were on standby and ready to supply power to the grid as soon as the grid was ready to take it. Unfortunately it is a complex procedure to restart a power grid and in the meantime Pickering ran out of steam and had to shut down. Three units at Bruce and one at Darlington were ready and began sending power to the grid as soon as the grid operator requested it.

The CANDU reactors proved their flexibility and reliability by quickly recovering from a massive grid failure. But what about hydro, coal and other generating stations? The turbines can spin the generators but no power comes out until the generator field coil (stator) is energized, and this energy is supplied by the grid. They are virtually useless machines until some external supply of electricity can be found. It was the CANDU reactors that allowed the other generators to eventually start up.

There is no better choice for electricity supply than flexible, reliable, GHG free and inexpensive CANDU.

In This Issue

With the exception of a couple of notable heat waves, this summer has been unusually "normal" and I hope everyone got a chance to enjoy it safely! It was also good fare for 100 or so attendees from six countries at the **12th International Conference on CANDU Fuel** in Kingston, Ontario, which the lead article describes. This is followed by a summary report by **Blair Bromley** and **Hossam Gaber** on the first **Canadian Workshop on Fusion Energy Science and Technology (CWFEST-2013)** at the University of Ontario Institute of Technology (UOIT) in Oshawa, Ontario, with about 50 attendees.

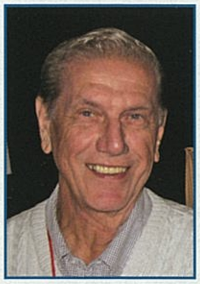
There are three technical papers in this issue dealing with U-233 processing, fusion technology and a design feature of the EC6 reactor to cope with severe accidents.

CNS member and McMaster Nuclear Reactor tour guide **Curtis McEwan** writes about how the tour affects people's perception of nuclear technology and radiation, and CNS member **Don Jones** writes about the advantages of the EC6 over the Westinghouse AP1000 when connected to the Ontario power grid.

There are the usual sections of General and CNS news, and last but never least **Jeremy Whitlock** uses the couch in his **Endpoint** (located at the end).

Your comments and submissions are welcome! Please note the CNS office has moved (see pages 3 & 46).

From The Publisher



Society activities

The Budget

Members of the CNS Council, and especially the Executive Committee, have been extremely occupied over the past few months with several pressing issues.

Prominent among those issues is the sudden change in the financial health of the Society. After several years of achieving a surplus income, 2013 is predicted to result in a significant loss.

As members know, the CNS has typically organized and run a number of conferences and courses each year, and, up to now, most of those events have netted a surplus, often significant. For example, Ken Smith, our Financial Administrator, reported that the average net income from Annual Conferences over the past 14 years was about $80K. The 2013 one, while technically and socially very successful, resulted in a surplus of less than $15K. This reflects smaller sponsorships from our generous but hard-pressed industry.

Further, the only other conference this year was the smaller, specialized CANDU Fuel one, reported in this issue of the Bulletin. Again, technically and socially it was very successful but the net surplus will be small.

As a consequence, Council decided to try to aim for a break-even budget for 2014. That has resulted in some strong discussions and difficult decisions, such as cutting programs that various members cherish. A positive note is the offer from AMEC – NSS of free office space. (Note the new address elsewhere in this issue.)

Incorporation

As a federally incorporated but non-profit organization the Society must file for what is called "Continuance" under the recent new Canada Not for Profit Corporations Act. This must be done before the fall of 2014.

Unfortunately some of the details involved with the transition turned out to be more complex than expected which resulted in many discussions about needed changes in our By Laws. Initial steps were taken at the Annual General Meeting held immediately before the Annual Conference in June. A Special General Meeting will be held November 3 in Toronto to obtain members consent on a set of revised By Laws. That will clear the way for a formal vote on Continuance at the 2014 AGM.

Interventions

After decades of staying out of the public debates on our nuclear program, the CNS Council recently decided to intervene in public hearings. The first was the hearing of the Canadian Nuclear Safety Commission on the renewal of the Operating Licence for the Pickering NGS last May. That was reported in the June issue of the Bulletin and the CNSC positive decision is noted in this issue. More recently, the CNS submitted a statement to the Long Term Energy Plan forum of the Ontario government and a brief to the Joint Environmental Hearing on the Deep Geologic Repository planned for the Bruce site. The formal submissions are posted on the CNS website.

CNS members are encouraged to participate in these public debates – but as individuals - NOT as representatives of the Society. Hearings, such as the one on the Bruce DGR, bring out a swarm of individuals with strong negative opinions, usually with no scientific basis. Knowledgeable members can help counter these views.

Succession planning

At the last Council meeting Past President John Roberts proposed that those in or associated with Council who have on-going roles should have a succession plan. I fall into the category.

After more than two decades of involvement with this Bulletin it is long past the time for me to withdraw. That means recruiting members to fill the roles I currently occupy. As "publisher" I have the basic responsibility to manage the Bulletin as a business component of the Society. Some years ago, despite misgivings by some, it was accepted that to make the Bulletin essentially financially self-sufficient, advertising should be sought. So, a sub-task is seeking advertisers and maintaining relations with them.

Dealing with our printer, Vincent Press in Peterborough, Ontario, for many years, has been a very positive experience. Over all that time, I have dealt with their General Manager, Andrew McCulloch, on a "hand-shake" cordial basis without any problem. Their lay-out person, Liz Kubica, is phenomenal in taking the raw material we send and creating the attractive publication you all receive.

Editor Ric Fluke selects the technical papers and commentaries but we work cooperatively in putting the material together.

Finally, I have been "reporting" on conferences and other activities, not as publisher but because I enjoy doing it.

So, as part of the Council's decision about succession plans I am seeking expressions of interest from members for any of the above roles. While expenses are covered there is no pay. So I address this primarily to recently retired members. Please contact me: e-mail: fboyd@sympatico.ca; telephone: 613-823-2272.

Fred Boyd

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~ Cover Photo ~

Fuel bundles manufactured at Cameco Fuel Manufacturing are used to generate electricity in Candu reactors.

Photo courtesy of Cameco Fuel Manufacturing Inc.

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

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12th International Conference on CANDU Fuel
Another Successful Fuel Conference

by FRED BOYD

With the active participation of over 100 delegates including representatives of six countries plus the International Atomic Energy Agency, the **12th International Conference on CANDU Fuel,** held in Kingston, Ontario, September 15 to 18, 2013, was truly a successful international event. Countries represented were: Argentina, India, Korea, Romania, Sweden, and the USA.

The conference was structured with a plenary session on the Monday morning and two parallel technical sessions that afternoon, all day Tuesday and Wednesday morning.

Although CANDU fuel has performed well a number of the presentations were on a modified design of the standard 37 element bundle called 37M which is now being loaded into the Darlington reactors. The renewed interest in thorium was also the focus of several presentations.

The conference was held at the Holiday Inn Waterfront Hotel which made it very convenient to have the conference dinner on board a cruise boat plying the St. Laurence through some of the famous Thousand Islands.

Following the traditional pattern, the conference began with a reception on the Sunday evening but one with entertainment. Following greetings from Kingston Mayor, Mark Gerretsen, MPP John Gerretson, MP David Sui and RMC Principal Harry Kowal, the delegates were entertained by a Scottish pipe and drum group and Scottish dancers, all cadets at RMC.

A modest-sized but energetic Organizing Committee, headed by **Paul Chan**, a professor at the nearby Royal Military College, included a number of his fellow faculty members. They chose the theme of *CANDU Fuel – Safe, Reliable and Flexible* and put together a program with both breadth and detail which kept most of the attendees engaged until the end of the conference.

A set of eight plenary presentations filled the opening session on the Monday morning.

Beginning the session, **Luis Alvarez** of the Comisión Nacional de Energía Atómica (CNEA) gave an *Overview of Activities on CANDU Fuel in Argentina.*

He began by noting that Argentina has two nuclear plants operating and one in final construction. Operating are Embalse (CANDU design) and Atucha (a German PHWR pressure vessel design). Construction of Atucha 2 is underway after a pause of several years.

Embalse started operation in 1984. From the beginning Argentina planned to manufacture its own fuel. Fabrication began in 2000 and continuing improvements have been made. Currently they are studying the use of SEU (slightly enriched uranium).

Dé Groenevld, recently retired from AECL – CRL, offered a researcher's view of the development of domestic CANDU fuel, in his presentation entitled: *Critical Heat flux and heat Transfer Enhancements in Nuclear Fuel Bundles- a Review of the Past 50 Years.*

He began with commenting that there is a wealth of knowledge hidden (at CRL and elsewhere) that has mostly been forgotten.Much time has been spent 'reinventing the wheel' he said. In particular many ideas about critical heat transfer have been forgotten, he added. He mentioned a film made by the National Film Board several decades ago, on a test called U 111,that had been lost until recently.

Tests were done in NRU loops between 1955 and 1975 which, he said, showed fuel could be operated at conditions beyond (computed) critical heat flux without problem. With the current licensing climate, he opined, such in-reactor tests would be impossible.

Further ideas explored included: doubling the length of the bundle; interlocking bundles; increasing height of the pods. A design of a solid bundle with tubular holes was among the many variations, he noted.

A view from India was provided by **Nudurupati Saibaba**, Chief Executive, Nuclear Fuel Complex, who spoke on: *An Integrated Approach for Safer, Productive and Reliable PHWR Fuel Manufacturing at NFC.*

He began with a quick overview of the Indian nuclear power program. There are now 21 plants in operation, 18 of which are PHWR design, 3 PWR. The PHWR are Indian developments of the Douglas Point design of the 1960s. The fuel designs for the PHWR are similar to those for CANDU. The early plants use 19 element bundles, the more recent, larger (700 MWe) units use 37 element fuel.

He briefly described their extensive fuel manufacturing facilities, much of it automated. They are studying the use of SEU (slightly enriched uranium) and have tested 51 bundles to date.

Uddharan Basak, of the International Atomic Energy Agency (IAEA), outlined that organization's activities related to PHWR fuel under the title *IAEA Activities on Fuel and Fuel Cycles for PHWRs.* These include: technical cooperation; organization of meetings and conferences and publication of "state-of-the art" information.

He noted four conferences on HWR fuel over the past decade: a general one in India in 2006; fuel design, fabrication and production in Argentina in 2009; integrity during operation in Romania in 2012 and a very recent one on advanced fuel cycles in India in April 2013.

A technical meeting on Management of Used Fuel from Water Cooled Reactors will be held in Vienna in November 2013. In addition a Coordinated Research Project (that includes AECL) was established last year and runs to 2015.

After a break, **Bill Kupferschmidt**, Vice-president, AECL, presented his views on *Advanced Fuel Development at Atomic Energy of Canada Limited – What does the future hold for CANDU fuels ?*

He listed key attributes of a nuclear energy system of the future: safety and reliability; availability; good fissile utilization; environmental stewardship; proliferation resistant; cost competitive. To accompany these he listed his key points for fuel research as: expand utilization; develop alternative fuel cycles; increase flexibility; expand recycling; increase safety and reliability; decrease environmental impact, improve proliferation resistance.

He continued with some topics being pursued at AECL, such as:

- Development of mixed oxide (MOX) and thoria fuel
- Examine internally cooled annular fuel
- Improve bundle fabrication
- Develop fuel for super-critical water reactors

To a question about reprocessing fuel be commented the once through system is working well and is competitive.

The first mention of the new "37M" fuel was given by **Harley Hughes** of Ontario Power Generation, who titled his presentation: *Implementation of Modified 37-element Fuel Bundle at theDarlington Nuclear Generating Station – an Overview.*

The essence of the new "37M" fuel bundle is a decrease in the diameter of the central element of a 37 element fuel bundle from 13.1 mm to 11.5 mm. This is to achieve a higher coolant flow around that element which had the leas margin to dry-out.

Hughes mentioned the four steps of: developing man ufacturing process; out-of-reactor tests; demonstratio irradiation tests; full implementation. Tests were done i two channels followed by analyses for a full core. It wa shown that the mechanical performance was unchanged there was no change in the analyses for Design Basi Accidents, and the trip coverage was improved.

The new fuel is now being loaded into all of th Darlington units. It was noted that this is the first chang in fuel design for Canadian power reactors in 20 years.

A regulatory perspective was pre sented by **Michel Couture** of th Canadian Nuclear Safety Commissio under the title: *Fuel Performance i Aging CANDU Reactors – a Quic Overview of the CNSC Regulator Oversight Activities of the Past 1 years and the Lessons Learned.*

He began by noting three steps in th review – ageing mechanism; potential impact on fuel safety margins. The CNSC has issued three relevant docu ments: *RD-334, on Aging; RD-310 on Safety Analyses; S-9 on Reporting Requirements.* Some of the aging mecha nisms, he mentioned, include: pressure tube deformation corrosion; plugging and fouling; material deterioration.

Couture acknowledged that, over all, CANDU fue performance has been excellent but aging can lead t changing conditions. The CNSC will be monitoring th situation closely.

The final plenary presentation wa presented by **Catherine Cottrell** o Candu Energy Inc. on behalf of Jerr Hopwood, who could not be present

Cottrell began by noting that Cand Energy was now two years old and "u and running"

She noted that CANDU units use 3 per cent less initial uranium than PW or BWR units. The latter discharge fuel with a highe U 235 content than natural. Recycling processes hav now been developed to the point that recycled uraniu (RU), without the fission products in spent fuel, is les expensive than natural uranium (NU). China is partic larly interested in using RU in their two CANDU units

The development to date has involved diluting the R with depleted uranium (DU) from enrichment facilities t produce what is described as Natural Uranium Equivalen (NUE), which would have the same U 235 content as na ural uranium. NUE has been shown to be essentially ider tical with natural uranium and consequently performs th same in a CANDU. The Chinese regulatory authoritie have agreed and full approval for the use of NUE in th Qinshan reactors is expected this year.

Prior to lunch on the first day all the attendees were shepherded outside for a group photo – a tradition from the beginning of the CANDU Fuel conferences.

At lunch **Major Paul Hungler**, who is attached to the SLOWPOKE reactor at RMC, gave a short but interesting talk on two diverse but interesting applications of the small reactor. One involved analysis of moisture ingress into the rudder structure of a small aircraft by using neutrons, where they were able to detect as little as 5 microlitres inside the honeycomb structure. For the other he again used neutrons to see inside an ancient small hollow Chinese statue to see if the maker had left a mark. In both cases the technique was successful.

That afternoon, all day Tuesday and Wednesday morning were devoted to two parallel sessions of technical papers. The headings for the sessions were:

- Modelling and Computer Code Development
- Safety and Operational Margin Improvement
- Fabrication
- Performance, Reliability and Operating Experience
- Advanced Fuel Cycles
- Design
- Spent Fuel Bay Operation

At the Tuesday lunch two presentations were made of the recently created CNS Fuel Technology award. Both were for *"Outstanding lifetime contributions to the development of CANDU fuel technology"*. The award winners were **Harve Sills** and **Colin Orpen.**

On the Tuesday evening the organizers arranged a dinner boat trip. The modern vessel chosen comfortably accommodated the hundred plus delegates and guests on one level under a plexiglass cover than enabled full view of the St. Lawrence River and the many islands passed on the hour and a half trip downstream and similar return. The weather cooperated, providing a moonlit return.

The conference was organized and run by a com-

Award winners Harve Sills and Colin Orpen.

mittee chaired by Paul Chan of Royal Military college and included: Maria Iligan; Hugue Bonin; Mark Floyd; Emily Corcoran; Brent Lewis; Ben Rouben; Paul Hungler; Kathy Nielsen; and Bob O'Sullivan of the CNS office.

Our special thanks go to John Perreault, also of RMC, who took photographs of all of the events and offered them to the CNS Bulletin.

The conference was supported by a number of organizations, as follows: Cameco Fuel Manufacturing; Cantech Associates; UniTech Services; Royal Military College; Canadian Nuclear Safety Commission; AMEC; IAEA; GE Hitachi; Candu Energy; Stern Laboratories; Ontario Power Generation; Power Workers' Union; Candesco; Canadian Nuclear Society,

A CD with all of the technical papers and most of the other presentations will be available from the CNS office later this fall.

Scenes from The Conference

First Canadian Fusion Workshop

Following is a slightly edited version of a report prepared by Blair Bromley and Hossam Gaber.

The first ***Canadian Workshop on Fusion Energy Science and Technology (CWFEST-2013)*** was held August 30, 2013, at the University of Ontario Institute of Technology (UOIT) in Oshawa with over 50 participants.

This workshop was co-sponsored by the Canadian Nuclear Society (CNS) and the Toronto Section of the IEEE (Institute of Electrical and Electronics Engineers). It was an embedded event held in conjunction with the *Smart Energy Grid Engineering (SEGE'13)*. The workshop ran from approximately 8:00 am to 5:00 pm, with 9 speakers and two panel discussions.

The idea of a Canadian fusion workshop was initiated by Professor Gaber, who invited Dr. Bromley to join in the organization of the event and the invitation of selected speakers. There were over 50 workshop attendees, including many students from UOIT, and representatives from ANRIC Enterprises, HOPE Innovations, Candu Energy Inc., Bruce Power, Babcock & Wilcox, DRDC, OSPE, etc.

Opening remarks were presented by MPP Donna Cansfield (former Energy Minister) and UOIT Professor Brent Lewis, Dean of the Faculty of Energy Systems and Nuclear Science (FESNS). They congratulated the organizers, volunteers, speakers and participants and offered encouragement in the pursuit of developing new energy technologies (including fusion) for the benefit of society.

Ms Cansfield encouraged fusion proponents in both the public and private sectors to send submissions to both the provincial and federal levels of government, written in what she metaphorically called "*Canadian Tire Language*". This strategy, she said, will help legislators, policy advisors, and their assistants to grasp ideas quickly, thereby increasing the probability of political support and action.

Professor Hossam Gaber and Dr. Bromley jointly opened the workshop. Bromley moderated the question period and panel discussions throughout the day. There was a rich and diverse selection of speakers, covering various technologies and aspects pertaining to fusion energy development, including the following:

- Dr. Henry Xianjun Zheng, Chief Scientist, HOPE Innovations Inc., Mississauga, ON
  - o *Fusion using a Focal Region of Multiple High Current Plasma Beams.*
- Mr. Michael Delage, VP, General Fusion, Burnaby, BC.
  - o *Acoustically-Driven Magnetized Target Fusion.*

CWFEST-2013 speakers.

- Professor Robert Fedosejevs, Department of Electrical and Computer Engineering, University of Alberta, Edmonton.
  - o *Laser Inertial Confinement Fusion - Advanced Ignition Techniques.*
- Professor Chijin Xiao, Department of Physics, University of Saskatchewan, Saskatoon.
  - o *Magnetic Fusion and Tokamak Devices.*
- Mr. Pat Carle, Department of Physics, Queen's University, Kingston, ON
  - o *Plasma Diagnostics in Fusion Energy Research.*
- Dr. Hamid Shahani, President, Norax Canada, Saint-Romuald, QC
  - o *Engineering Issues in Fusion Reactor Design and Alternative Concepts.*
- Mr. Richard Barnes, ANRIC Enterprises Inc., Toronto, ON
  - o *Development of Standards in Fusion Reactor Technology.*
- Dr. Hugh Boniface, AECL – Chalk River Laboratories, ON
  - o *Tritium Handling Technologies.*
- Dr. Andrew Davis, Engineering Physics Department, University of Wisconsin, Madison.
  - o *Fusion Neutronics Issues and Developments.*

All of the presentations were comprehensive, generating many questions both following the presentation and during the panel discussions in the morning and afternoon. A number of key observations were made:

- Whatever technology is pursued for fusion energy development, there remain numerous unknowns, particularly in engineering and materials science that must be addressed eventually to achieve both practical and economical fusion energy.
- Canada needs a revived and renewed national fusion program to help coordinate fusion R&D activities across several provinces, organizations and institutions in both the public and private sector. There needs to be more communication and cooperation between various levels of government, to ensure a sustainable program that will help lead to commercial development and exploitation of fusion energy.
- Canada needs to commit itself to a dual level of participation – Canadian representatives (scientists, engineers, technologists, etc.) involved in international programs and projects, as well as domestic programs and projects in both theoretical/computational and experimental studies. The challenge is to find the right balance of activities, and to secure stable, committed long-term funding from both private and public sources. It is not in Canada's best interest to remain isolated from the rest of the world in the area of fusion science and technology. Budget difficulties of federal and provincial governments are recognized.
- Canada's obvious strength is in the production and handling of deuterium and tritium. Without Canadian fusion fuel supplies, world activities in fusion energy development will be very difficult.
- A challenge faced by Canada is the lack of a "farm team" for highly qualified and skilled experts in the area of both experimental and computational/theoretical plasma physics and other fields of relevance to the analysis and design of fusion reactors. There are few university programs offering sufficient courses or studies, and many graduates who are able to obtain such skills must often leave Canada to work in other countries (such as the U.S.A., and Europe).
- In addition to international programs/projects, suc as the National Ignition Facility (NIF) in the U.S.A and the International Thermonuclear Experimenta Reactor (ITER) in France, China is pushing ahea with a comprehensive, multi-disciplinary fusio program, and is examining all options and possibil ties. Canada needs to get back on board so that i will not become completely dependent on foreig expertise. This will require more effort and leade ship on the part of fusion energy proponents an advocates to convince both the public and privat sectors in Canada to make the necessary investment in people, programs and projects.

CWFEST-2013 was considered to be an enormou success, stimulating much discussion and interes among all the participants, particularly the student Much networking and informal discussions occurre during the coffee and lunch breaks (with exceller food!). It was also successful in bringing togethe various fusion research groups from across Canada to meet face-to-face, and to build the foundation for future cooperation and potential collaboration Based on this success, it is hoped and anticipated tha the next CWFEST will be held in 2014 or 2015.

CWFEST was planned and organized by Professo Hossam Gaber (UOIT, SEGE'13 Chair) and Dr. Blair I Bromley (AECL – Chalk River Laboratories and Chai of the CNS Fusion Science and Technology Division Assistance and logistics support were provided UOI students and CNS members Ray Mutiger (CNS-UOI chair), Terry J. Price, Gabriel Aversano, and othe UOIT staff and students.

For more information about the CWFEST-2013 (e.g speakers, presentations, photos, etc.), one can visit th CNS Fusion Science and Technology Division (CN FSTD) web page, at http://cns-snc.ca/CNS/fusion/ and also the SEGE'13 conference website, a http://ewh.ieee.org/conf/sege/2013//

CWFEST-2013 speakers and participants.

A Possible New Method for Processing Uranium 233[1]

by DON WILES[2]

[Ed. Note: The following paper was submitted to the Bulletin.]

In the recent few years there has been a renewed interest in the possibility of using uranium-233 as a reactor fuel. There are several interesting advantages of this fuel, the most important of which is that Plutonium-239 and other transuranium elements are not produced in any of the reactions involved.

There are, however, also several disadvantages of uranium-233: it is not found in nature and it is difficult to make. One of the most severe of the most severe problems is the difficulty of producing and purifying Uranium-233. This production is done from the use of natural thorium (Th-232) as a target in normal nuclear reactors. Thorium-232 is not fissionable except at high energies, so the processes are conducted in normal U-235 reactors, mixed with pellets of ThO_2. This reaction occurs in the following series:

Th-232 – (n,γ)-> Th-233 – β-> Pa-233 – β-> U-233 fission [1]

Ultimately, the U-233 can build up in concentration so that the reactor can become a breeder, and produce more U-233 than is consumed, or produce Uranium-233 for other reactors.

The relevant data are given in Table I.

While this does produce the desired fissile product,

Nuclide	Th-232	Th-233	Pa-233	U-233
Half life	1.4×10^{10} a	21.8 m	26.98 d	1.59×10^{5} a
Decay	α	β	β	α, fission
σ (n,γ)	7.3	1450	42.5	45.3
σ (n,f)				531

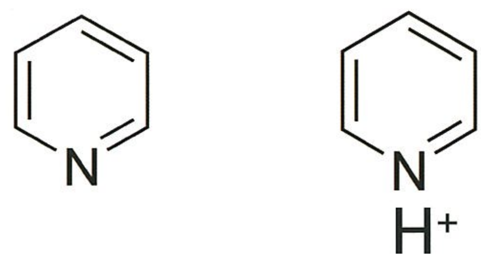
Table I. Data for the nuclides in Equation 1.

the problem now is how to retrieve it from its target thorium. The common procedure, Thorex, is not yet well developed. It is to use nitric acid to dissolve the ThO2 fuel and then presumably use tributyl phosphate to extract the uranium. The problem, as in so many cases of metal chemistry, is the stability of the metal oxides, especially in any aqueous system.

It has occurred to us that a quite different chemical procedure could be through a non- aqueous production of the anhydrous acid chlorides, followed by the selective volatilization of UCl_4. Although there may be several appropriate anhydrous acid chlorides, we have considered pyridinium chloride as being perhaps most advantageous. Pyridine is a cyclic nitrogen compound which readily adds an acid hydrogen ion.

It is readily prepared by the direct reaction of HCl with liquid pyridine by the simple reaction (in which we represent pyridine as Py, and pyridinium as PyH+)

$$Py + HCl \rightarrow PyH^{+} + Cl^{-} \qquad [2]$$



It might be advantageous to use gaseous HCl to prepare PyHCl, rather than the aqueous acid, although either method should be effective.

The components and product of this reaction have the following properties (where the data seem to be slightly uncertain).

	mp °C	bp °C
water	0	100
Pyridine	41.6	115.2
PyHC1	142	222

Table II. Data for the reaction components.

It is important to note from Table II that at the melting point of PyHCl, both any water present and any excess pyridine present will boil off. This is critical to avoiding the formation of Thorium or Uranium oxides. PyHCl is very hygroscopic at lower temperatures.

It is now clear that molten pyridinium chloride behaves exactly as does the more familiar aqueous hydrochloric acid, so we can have the reaction

$$ThO_2 + 4\ PyHCl \rightarrow 2\ H_2O + ThCl_4 + 4\ Py \qquad [3]$$

in which the water and pyridine would be driven off at the temperature of the molten PyHCl. Excess PyHCl could then be distilled off, presumably leaving the anhydrous metal chlorides to be separated by sublimation.

While we have not evaluated this reaction itself, the same procedure has been used in other contexts. Initially suggested by Kurt Starke[1], the reaction has been used to

1 This was inspired by a lecture given in Ottawa by Dave Torgerson, former Senior Vice President of AECL. He suggested that the Chemists should start to "think outside the box".

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dissolve ferro-columbium[2] and several other refractory elements[3] and has been used to prepare anhydrous UCl_4.[4] There is no reason to doubt that the reactions above are expected to produce anhydrous $ThCl_4$ and UCl_4.

Several critical questions remain. Also present in the thorium oxide target will be the usual range of fission products. Of these, some will be easily volatile, others may be either insoluble in the molten mixture or non volatile, while others may be volatile as the anhydrous chlorides. It is likely that the medium will be reducing, so that many of the fission products will be in lower valence states and thus less likely to form volatile chlorides. Table III gives our impression of the volatilities:

Volatile	Insoluble Chlorides	Volatile Chlorides	Uncertain Chlorides
Br, I, Kr, Xe	Rb, Cs, Ag	Zn, Ga, Ge	Cd, Y, Nb, Tc
	Sr, Ba, Eu	As, Se, Zn, Mo	In, Sn, Sb, Te
		Ru, Rh, Pd	Rare Earths

Table III. Relative volatilities of the fission products.

If it is found that the thorium oxide can be conveniently dissolved in molten PyHCl, then this process would present an alternative procedure for retrieving Uranium-233 for use in power reactors. In our own experiments, we have shown the solubility of UCl_4 in PyHCl, but we ha not yet been able to work with reactor- grade ThO_2.

Two important questions remain, which we have n been able to work on.

Firstly, it is not known how resistant PyHCl will b to the intense gamma radiation. It is possible that t Pyridine ring may be destroyed by the radiation, a thus the suggested process cannot become practic The other problem is the rate of dissolution of t ThO_2. Thorium oxide is known to be quite refracto and if the dissolution is too slow, then the procedu might not be practical. Nonetheless, it should likely useful to examine these aspects of the chemistry.

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Progress Towards Acoustic Magnetized Target Fusion: An Overview of the R&D Program at General Fusion

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Abstract

Magnetized Target Fusion (MTF) is a hybrid approach to fusion in which a self-organized plasma is compressed with the inertia of a conductive liner to conditions that fulfill the Lawson criterion [1]. This paper provides an overview of the science behind MTF and the ongoing research at General Fusion to design, test, and demonstrate the ability to produce energy using its acoustic MTF technology.

1. Introduction and Background

Magnetized Target Fusion was first proposed in the 1970's as a low-cost approach to fusion that combines the advantages of magnetic confinement fusion and inertial confinement fusion by working in an intermediate regime of plasma density and confinement time. The U.S. Naval Research Laboratory did pioneering work on the LINUS program [2], which was unique among MTF schemes by employing a liquid metal liner to address the traditional fusion challenges of heat extraction, tritium breeding, and neutron flux on structural components [3,4]. The liquid liner made the compression inherently repeatable, but at the time could not be accelerated to sufficiently high velocities to compress plasma within its thermal lifetime. General Fusion is pursuing an acoustically-driven MTF concept that makes use of modern servo controllers which precisely time piston impacts to create an acoustic wave in the liquid metal liner. This wave will compress the target plasma in less than 200 μs, similar to the practically achievable plasma lifetimes in modern self-organized plasma devices. An MTF reactor with the potential to achieve net gain can be developed given current technologies.

In General Fusion's design, the deuterium-tritium fuel is supplied as a pair of magnetized plasma rings, known as compact toroids (CT). The CTs are delivered to an evacuated vortex inside a volume of liquid lead-lithium eutectic metal (atomic ratio 83% Pb, 17% Li, hereafter referred to as Pb-17Li) for the duration of an acoustically-driven spherical collapse. The cavity volume is reduced by three orders of magnitude, raising the plasma density from 10^{17} ions/cm^3 to 10^{20} ions/cm^3, the temperature from 0.1 keV to 10 keV, and the magnetic field strength from 2 T to 200 T. The fusion energy will be generated during the 10 μs that the plasma spends at maximum compression, after which the compressed plasma bubble causes the liquid metal wall to rebound. Most energy is liberated as neutron radiation that directly heats the liquid metal. Using existing industrial liquid metal pumping technology the heated liquid metal is pumped out into a heat exchange system, thermally driving a turbine generator. The cooled liquid metal is pumped back into the vessel tangentially to reform the evacuated cylindrical vortex along the vertical axis of the sphere. Liquid Pb-17Li is ideal as a liner because it has a low melting point, low vapor pressure, breeds tritium, has a high mass for a long inertial dwell time, and has a good acoustic impedance match to steel, which is important for efficiently generating the acoustic pulse. The 100 MJ acoustic pulse is generated mechanically by hundreds of pneumatically-driven pistons striking the outer surface of the reactor sphere. The acoustic pulse propagates radially inwards, strengthened by geometric focusing from 1 GPa to 10 GPa at the surface of the vortex.

Acceleration of compact toroids (CTs) is a synthesis of two well-developed concepts: the spheromak plasma configuration and the railgun accelerator. A compact toroid is a self-organized spheromak plasma containing embedded toroidal and poloidal magnetic fields, which decays principally by resistive dissipation of the plasma currents over several hundred microseconds. A railgun switches stored electrical energy from a capacitor bank into two rails with a moving projectile acting as an armature providing a conduction path between the rails. This creates a variable-inductance line with expanding stored magnetic flux pushing the projectile and accelerating it. A CT accelerator differs from a railgun by replacing the armature-projectile with a compact toroid, which can then be accelerated to speeds in excess of 100 km/s. The CT accelerators in General Fusion's design are located at the poles of the evacuated vortex. The injected CTs travel to the center of the sphere and merge to form a stationary compressible plasma target. The plasma ions are Ohmically heated during merging by magnetic reconnection.

1. General Fusion Inc., 108-3680 Bonneville Place, Burnaby, BC V3N 4T5 (www.generalfusion.com)

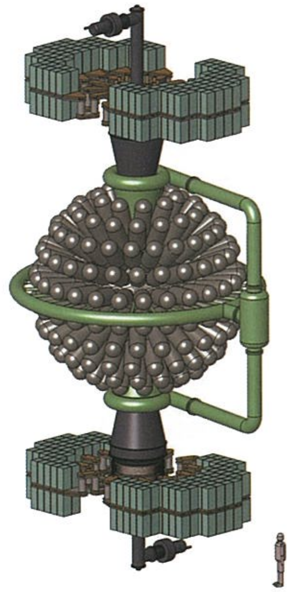

Figure 1: General Fusion's Acoustic Magnetized Target Fusion Reactor Concept.

For a future power plant, economics, neutronics, tritium supply, and reactor energy density need to be considered. The eutectic absorbs the bulk of the fusion products through elastic scattering and provides a straightforward means of extracting the energy. The thick blanket significantly shields the wall by reducing the neutron flux on the structure and by lowering the neutron energy spectrum [5]. The 4 pi coverage provides an enhanced tritium breeding ratio (TBR) of 1.6 to 1.8 [6]. The neutron multiplication factor results from the Pb(n,2n) reaction and also from the $^{7}Li + n \rightarrow {}^{4}He + {}^{3}H + n$ reaction as diagrammed by Moyer [7]. The challenge with a thick Pb-17Li liner is likely to be too much tritium production.

This paper summarizes General Fusion's activities during 2012 to prove the viability of its MTF technology. Efforts are focused on mitigating risks and testing full scale components for acoustically-driven compression of plasma in the proposed reactor, in order to validate the predicted plasma behavior and demonstrate net gain. The MTF program is divided into the following areas: Acoustics Driver, Plasma Injector, and in support of these, Numerical Simulation.

2. Progress on Acoustic Driver

The acoustic driver consists of a 100 kg, 300 mm diameter, hammer that is accelerated down a one meter long bore by compressed air. The hammer's position is measured as it traverses the bore and its speed is controlled by an electronic braking system. This control system directs the hammer to impact a stationary anvil at a precisely controlled time. The collision generates a well timed acoustic pulse that can then be coupled into liquid metal.

A recently constructed test stand for developing and improving the acoustic driver is shown in Figure 2. During the last year, 850 shots were made on this test stand including 39 shots with 50 m/s impact speed.

The best high speed timing performance recorded a sequence of 4 consecutive shots, at 50 m/s impact velocity, arrive within 2 us of the target time. The steady

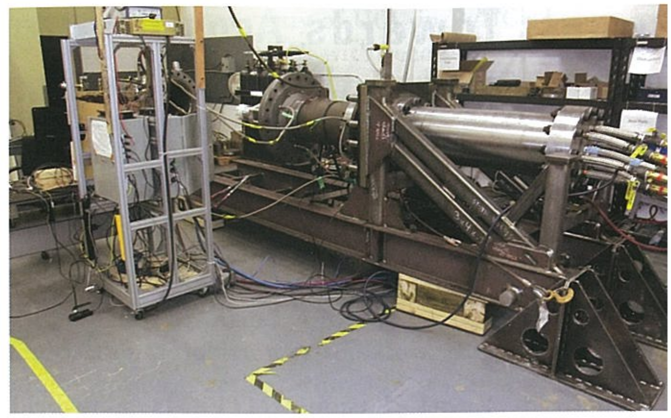

Figure 2: 'HP3b' acoustic driver test stand. The gr acoustic driver can be seen on the left hand side, while the large silver tube on the right, is an ener absorbing device used in place of liquid metal.

improvement in the acoustic driver's performance is result of improved control system signal processi and hammer launching hardware.

Work is ongoing to improve the system's shot to sh repeatability.

Testing is also progressing to find suitable mate als for both the hammer and anvil assemblies. So f four materials have been identified as candidates; Bohl Uddeholm 'Dievar', QuestTek 'Ferrium M54', Carpen 'AerMet 100', and Vascomax 'C300'.

Although the applied loads are similar, the mat rial requirements for the anvils and the hamme are slightly different. The anvils will be in continuo contact with molten metal, so they need to operate

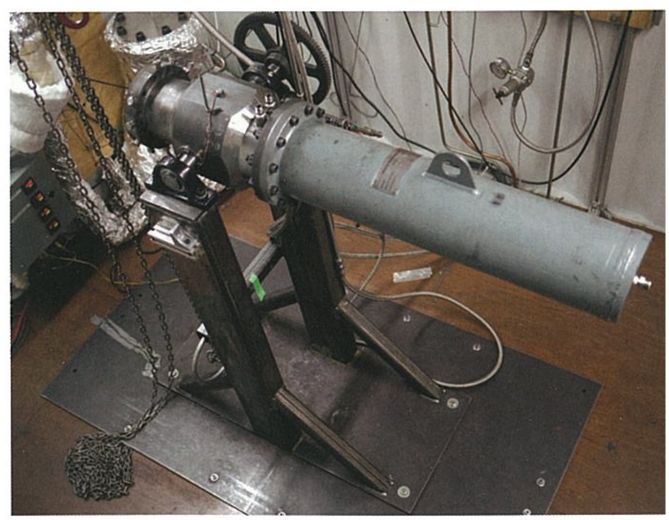

Figure 3: Mini-piston, in horizontal position, without lead tank installed. This machine, which is a 1/3rd scale version of General Fusion's full scale pistons uses an air- actuated hammer in a bore that impacts a stationary anvil. A molten lea tank can be fitted onto this device to study both the pressure wave propagation in the liquid meta as well as the behavior of materials when they exposed to liquid metals under high loads.

Figure 4: Pitting on liquid lead exposed anvil face after several 50 m/s impacts.

elevated temperatures. Whereas, the hammers don't operate at high temperatures, but they do have complex features machined into them, making them susceptible to failures originating from geometric stress concentrations. Dievar is currently under test as both a hammer and an anvil material. A full sized Dievar anvil, installed in the HP3b test rig, has seen 38 impacts at 50 m/s, as well as hundreds of low speed impacts. The part, so far, shows no sign of failure running at room temperature. Elevated temperature testing of the Dievar material was carried out on the Mini-Piston test rig shown in Figure 3.

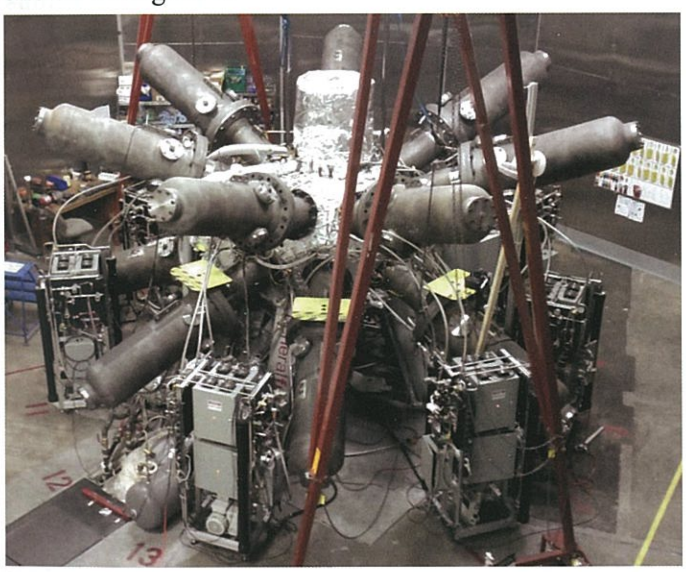

Figure 5: Mini-Sphere, a 1 meter spherical, liquid lead filled, tank with acoustic drivers mounted around the exterior, has 14 drivers, arranged in two rings of 7 drivers each. The hammers impact anvils that are in direct contact with the liquid lead, imparting pressure pulses into the molten metal. Lead is pumped around the inside of the sphere, creating a cylindrical vortex in the centre of the device. The inner wall of the vortex can then be imaged as pressure waves, travelling in from the radial pistons, converge and collapse the vortex.

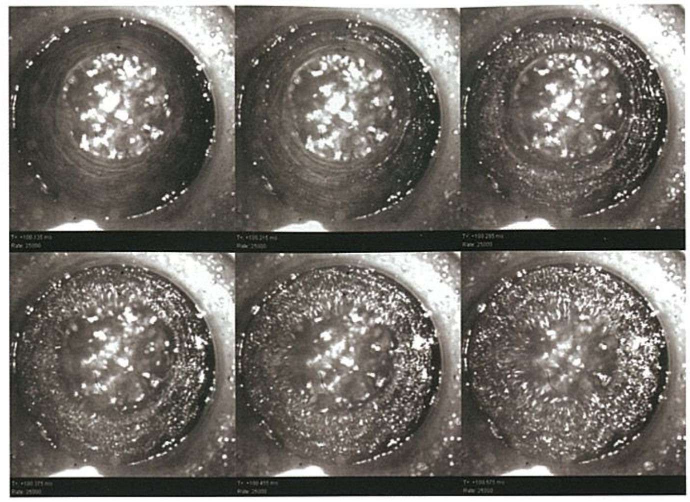

Figure 6: Vortex collapse from 7 m/s impact of 14 pistons filmed at 25,000 FPS. This sequence shows the first 480us of the collapse, divided into 80 us frames. The timing results were excellent for this 7 m/s shot, with a total arrival timing spread of: +48/-34 us (fig. 6).

Two samples of small Dievar anvils were tested on this machine with impact speeds of 50 m/s - 55 m/s. In total, 13 tests were run on these samples with impact speeds at, or over, 50 m/s. For a given impact speed, the stresses in the small anvils are expected to closely mimic the stresses in the full size anvils. The tests were done at elevated temperature and the anvil faces were in direct contact with molten lead. Although no evidence of cracking was found in these test pieces, as seen in Figure 4, significant pitting was observed on the lead interface surface. It is thought that this is likely due to cavitation.

The Mini-Sphere, shown in Figure 5 was commissioned with various combinations of drivers during which pressures and strains in the system were measured. The goal of this program was to validate the structural models of the sphere's various components and evaluate the mechanical integrity of the device. Several deficiencies were identified and now design improvements are being implemented.

After the sphere's commissioning was complete, ten shots were made with the full complement of 14 pistons firing under servo control. These shots had impact velocities ranging from 7 m/s to 10 m/s.

The resulting vortex collapses were filmed using a high speed camera and the imagery was compared to the results of CFD simulations. Figure 6 shows the progression of the vortex wall as the pressure waves converge. The wall of the vortex turns to a spray soon after the arrival of the pressure wave. This effect is thought to be from a combination of Richtmyer-Meshkov instabilities (RMI) on the vortex surface and a poorly formed cavitation region in the lead, generated by pressure pulse reflection very close to the vortex wall. Work continues to both improve the error in arrival time spread, and to increase the impact velocity. The current goal is to achieve an impact timing error spread of +/- 10us with a impact speed of 20 m/s. Work also continues to understand and control the spray that is generated during the collapse of the vortex.

2.1 Cavity collapse simulations

Extensive computational fluid dynamics (CFD) and finite element analysis (FEA) numerical testing has been performed to design the Mini-Sphere (Figure 6). Models were made to predict pressure wave propagation and the shape of vortex collapse by testing different piston impact velocities, impact timings, piston positions, and reactor shapes. Due to the small size of the Mini-Sphere, the 14 pistons are expected to compress the vortex from the center towards the poles. Simulations have shown that compression from the poles to the center on a larger system can be accomplished by timing the piston impacts to create an oblate spheroidal wave front.

Identifying and reducing potential damage to the Mini-sphere and its auxiliary systems is an important role of modeling. For example, estimations of "Water hammer" behaviour in the Mini-Sphere have indicated that the pressure wave initiated by the pistons will enter the pumping system (Figure 7). Methods for mitigating damage to the pipes and Pb pumps

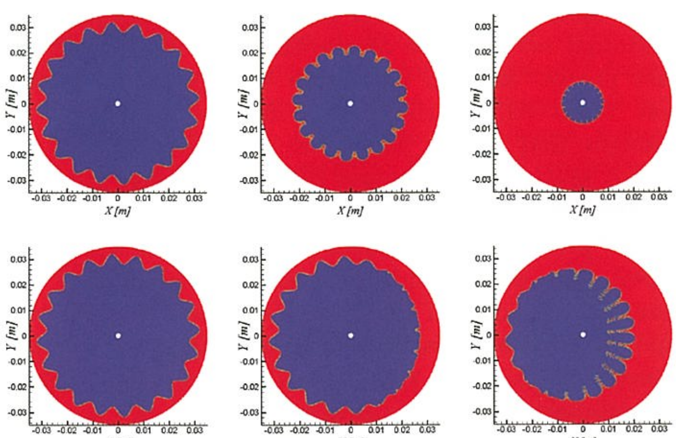

Fig. 7: Effect of the asymmetry of the imploding wave. First row shows collapse of the initially perturbed air cavity by perfectly symmetric imploding cylindrical pressure wave. Second row shows collapse of exactly the same cavity when the pressure wave is generated by a single piston (pressure wave arrives from the right). Difference in the perturbation growth is due to different geometrical convergence experienced by the air-cavity during the collapse for the results shown in rows one and two. Simulations were performed on the set of parameters relevant to Mini - Sphere using OpenFOAM CFD software.

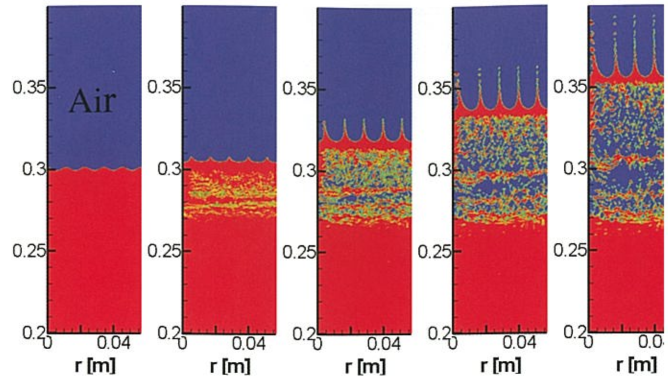

Figure 8: Effect of initial free surface imperfectio on the characteristics of the detached Pb layer formed as a result of interaction between pressu pulse and free surface (Pressure wave travels from Pb into air). Spiky structures propagating in the air are due to Richtmyer-Meshkov instability developing after the pressure pulse hits the interface. Simulations are carried out in a planar geometry on a set of parameters corresponding t mini piston experiments.

are being investigated and simulated to calcula the forces on the supporting structure resulting fro asymmetric firing of the 14 pistons.

With Mini-Sphere and Mini-Piston became ful operational, extensive numerical simulations have be carried out to improve our understanding of the vario phenomena involved in the process. The main focus h been on exploring different factors affecting the quali of the lead shell surface as it collapses the cavity. is well-known that interaction between pressure wa and free surface originates development of Richtmy Meshkov instability that may potentially affect the ef ciency of the plasma compression. Thus the ability predict reliably a threshold for the acceptable level initial perturbations (i.e. imperfection of the vortex su face, timing of the pistons, non-uniformity of Pb et is very important. Effects of geometrical convergenc perturbation amplitude, perturbation mode, asymmet of the imploding wave and rotation were thorough studied numerically using previously developed mode and validated against existing numerical and expe mental results where possible.

Typical results are shown in Figures 7 and 8. Figu 7 emphasises the effect of wave asymmetry on the c lapse of initially perturbed cylindrical air cavity, whi figure 8 demonstrates effect of geometrical conv gence (compare figure 7 and figure 8 for cylindric and planar geometries with similar initial perturb tion and pressure pulse).

For our hydrodynamic simulations we use OpenFOA CFD software while the input is frequently provid by FSI and structural simulations performed wi LS-Dyna or Ansys Explicit STR FEA software.

3. Progress on Plasma Injector

General Fusion has two types of plasma injectors, a small direct formation device (MRT) and larger more energetic devices (PI1 and PI2). A schematic of the small injector is shown in Figure 9 (a) and the two large injectors are pictured in Figure 9 (b). The second large injector was constructed and commissioned in 2012. The large devices have both a formation section and an accelerations section. The various steps involved in creating and compressing a CT in the large plasma injector are shown in Figure 10.

The goal of the large injector is to have a magnetic and temperature life in the pot of greater than 100 microseconds. In mid-2012 General Fusion believed this had been achieved. The early part of the year was marked with good acceleration performance and in June GF achieved good separation of the CT in the injector's flux conserver from the accelerator section as shown in Figure 10. Unfortunately a few days later it was determined that the temperature as measured by Thomson Scattering was falling off in ~30 microseconds. Several months of testing revealed that the primary cause of the cooling was loss of heat confinement due to poorly formed and maintained flux surfaces.

Careful investigation of the possible input parameter space coupled with improvements in computer simulation resulted in greatly improved heat confinement in formation. Confinement improved to the point that compressional heating via contraction of the CT and/or ohmic heating of the plasma was observed during formation. This result is shown in Figure 12. Heating continued for ~200 microseconds until the magnetic surfaces crossed through an instability resulting in distortions in the flux surfaces and loss of confinement.

Subsequent acceleration of the well-formed CT indicated adiabatic heating of the CT in compression. A CT formed at location 118 cm with 0.2T, 40 eV, and 0.5E14 cm-3 when accelerated had 0.8T, 160 eV, 4E14 cm-3 at location 352 (2x radial compression) and 3.0 T, 640 eV, and 3E15 at location 493 (further 2x radial compression). Note the 640 eV temperature is uncertain because it has not yet been possible to verify it with Thomson Scattering as the signal is lost at that temperature and density.

General Fusion has continued to made progress in forming and accelerating compact toroids (CT) and is nearing the requirements for long lasting, stable,

Device	Plasma Type	Temp eV	Temp Time μs	Density cm^{-3}	Mag T
MRT	He	30	70	1E16	1.5
MRT	D	75	100	2E15	1.2
PI1 formation	D	100	200	1E14	0.4
PI1 @ 352	D	160	n/a	1E15	0.8
PI1 @ 493	D	>250	n/a	4E16	3.0

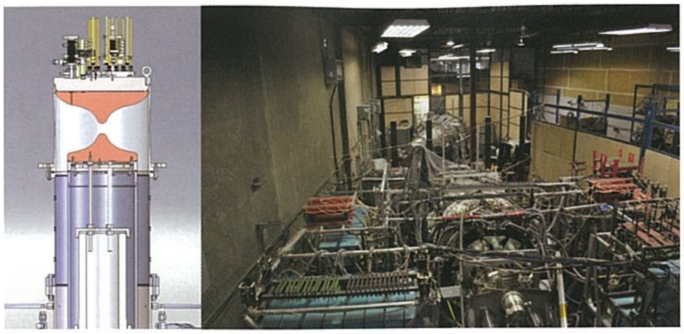

Figure 9: (a) Schematic of small plasma injector named MRT, diameter of injector is 30 cm. (b) Picture of large plasma injectors PI1 and PI2. PI1 and PI2 are designed and located to face each other for eventual CT merging experiments.

and hot CTs in the target chamber. A series of design changes were implemented and tested, eventually resulting in good formation and acceleration of CTs. The acceleration current now delivers most of its energy into acceleration, allowing it to reach elevated temperatures and magnetic fields. Formation efficiency is ~45% and acceleration efficiency is ~20% (energy in CT/discharge energy from relevant capacitor bank).

Performance achieved to date on both types of injectors is summarized in the following table.

All temperatures have been measured with Thomson Scattering which is General Fusion's standard temperature method. Ion Doppler, X-ray photodiodes, and neutronics are also used but each of these are line averages, vary during time (in the case of Ion Doppler, ion species become full ionized), or bulk measurements. This can result in errors and uncertainty due to plasma turbulence.

3.1 Computer Simulation of Plasma

Computer simulation of plasma at General Fusion is essential to understand the complex physics of our machines. Our primary simulation tool is the Versatile Advection Code (VAC), which is a shock- capturing magnetohydrodynamics (MHD) code. The version we use was augmented at General Fusion to include coupling to lumped circuits (the formation and acceleration capacitor banks) and additional physics like radiative cooling, plasma viscosity, etc. Other codes were developed in-house, for example to simulate compression of plasma to fusion conditions. As well as improving the simulations themselves, we also introduced more powerful techniques for analyzing simulation results, such as the safety factor profile, mode structure (Figure 13a), and magnetic surface stochasticity (Figure 13b).

Work focused on simulating the ongoing plasma injector (PI) and magnetized ring test (MRT) experiments. In the PI work the simulation provided valuable insights into the operation of the injector, leading to a number of design improvements. In the MRT work we introduced the use of a finite- element

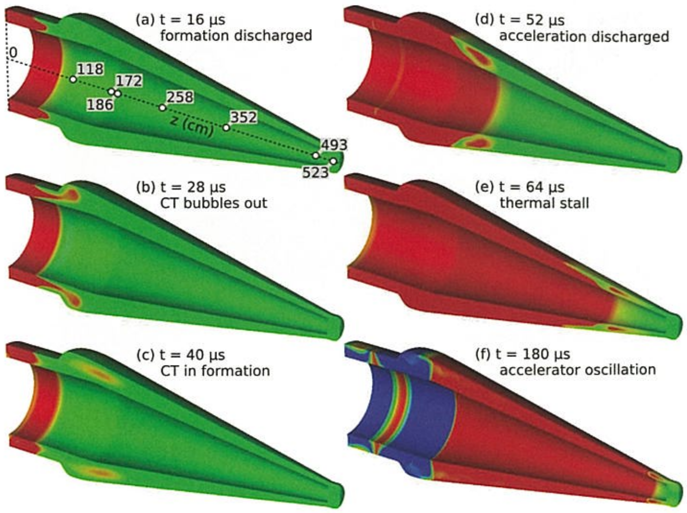

Figure 10: Simulation of poloidal current in the plasma injector done with VAC (red positive, blue negative). Axial positions of probe ports are marked by white circles in (a). The plots show the poloidal current as calculated in an axisymmetric magnetohydrodynamic simulation done with VAC, (Versatile Advection Code). (a) Initially, a voltage is applied to the formation electrode, which increases the toroidal magnetic field in the formation region. (b) The toroidal field interacts with the poloidal stuffing field to bubble out a CT. (c) The CT separates from the stuffing field and sits in the formation region. (d) A voltage is then applied to the acceleration electrode, increasing the toroidal field behind the CT and pushing the CT down the injector. (e) Sometimes the thermal pressure in the CT becomes larger than the pushing force applied by the acceleration current, causing it to slow down. (f) The energy capacitors and injector are analogous to an LRC circuit, so the accelerator voltage oscillates after pushing the CT to the target chamber.

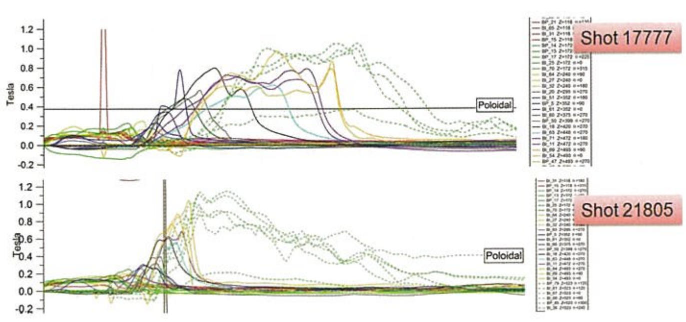

Figure 11: Plots of injector magnetic field displaying "pot" magnetic field separated from accelerator magnetic field. Shot 17777 only lasts 30 µs past the 493 position (yellow lines) while 21805 has 80 µs past the 493 position. Shots like 21805 were accompanied by hot temperature measurements from both ion Doppler and X-ray techniques.

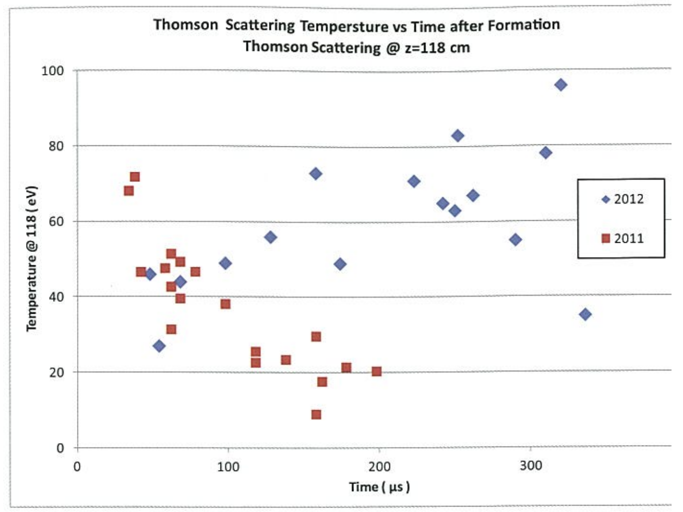

Figure 12: Composite time history shows that in 2011 the CT is formed at temperatures well above 50 eV and then quickly cools which is compared with 2012 data showing CT heating and good heat confinement consistent with closed flux surfaces

code (FEMM) to calculate magnetic field profiles the presence of iron components (Figure 14a). The profiles are part of the initial conditions required begin a MHD simulation (Figure 14b).

We advanced the use of 3-d simulations to reve behavior that cannot be captured by 2-d (axial symmetric) simulations. For example, a model the gas puff valves predicts a certain level of ma loading asymmetry and 3-d simulation shows h this can affect CT formation in the plasma inject

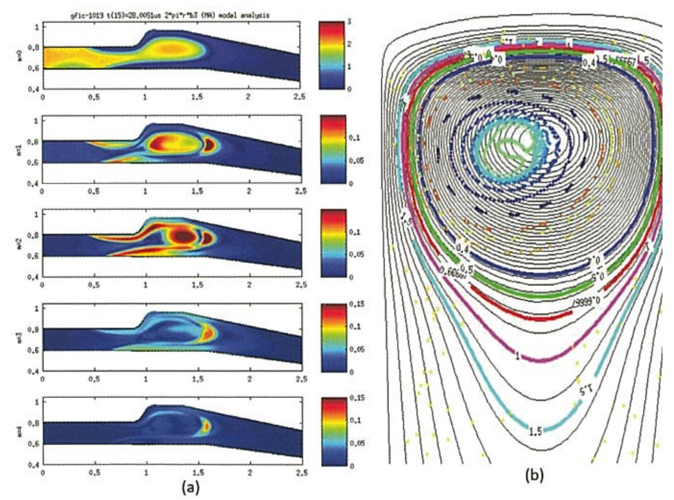

Figure 13: (a) Toroidal mode structure of a CT that has bubbled-out in a plasma injector. Top plot is axisymmetric component, 2nd through 5th plots show contribution of modes 1 through 4. (b Poincare plot of magnetic field in CT undergoing acceleration. The flux surfaces can become helical without loss of confinement. Each dot colour is a distinct magnetic field line. The solid lines indicate rational q surfaces.

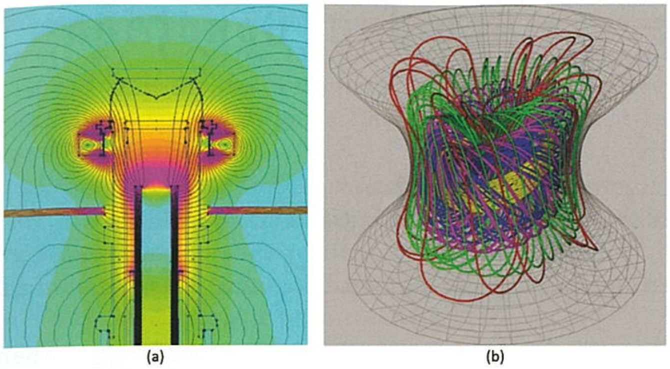

Figure 14: (a) Initial magnetic field configuration for MRT device as calculated by FEMM. Black lines show poloidal flux contours and colours show magnetic field strength (cyan low, magenta high). (b) Trace of magnetic field lines inside MRT pot as it is compressed by a shaped pinch.

Asymmetric magnetic signals predicted by simulation were similar to those being observed in reality. http://www.engineering.pitt.edu/LarryFoulke/

Other work addressed future design improvements and experiments. Simulations of the planned experiment to merge spheromaks from a pair of opposing plasma injectors reveal that large halo currents may form (Figure 15). As these currents may vaporize material from the wall, it is important to determine how to minimize them.

At the beginning of 2013 the following work is underway: improve the plasma thermal conduction model by addition of field-line following algorithm to VAC, generalize VAC to handle multi-block geometry, introduce the fusion-community CORSICA code for generation of plasma equilibria for simulation as well as for fitting of experimental data.

4. Summary

The previous year has seen much progress towards creating and compressing plasma and the outlook is now very encouraging. In particular, plasma densities of 10^{16} ions/cm^3 at >250 eV electron temperatures and up to 500 eV plasma ion temperatures have been demonstrated. Indications are that the formation region of the injector has achieved closed flux surfaces and that these surfaces are maintained during acceleration allowing for adiabatic compression and heating. Piston impact speeds of 50 m/s and servo-controlled impact timing accurate to ± 2 μs have been achieved. The 14-piston liquid Pb Mini-Sphere assembly for testing vortex generation and piston impact has been fully commissioned and is collecting data.

General Fusion is buoyed by recent progress on all fronts of the MTF program. Improvements in piston survival, liquid Pb handling, plasma temperature, acceleration efficiency, injector reliability, and regulatory matters have left the team and investors with a positive outlook on the coming year and the company's ability to meet goals.

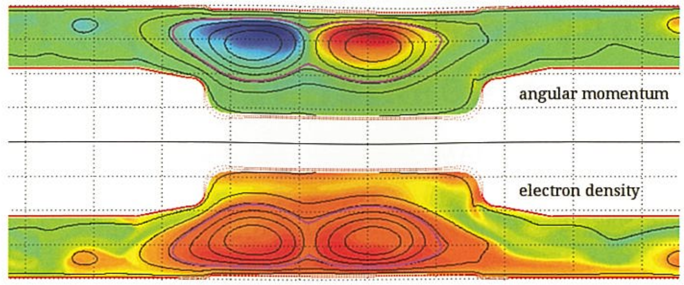

Figure 15: Two spheromaks of opposite helicity meeting in a drift tube with an inward expansion region. Top plot is coloured by angular momentum and bottom by electron density. Black lines show poloidal flux contours.

5. Acknowledgements

The authors would like to acknowledge the work of the entire General Fusion team for their ongoing efforts in the development of this technology. General Fusion is funded by private investors including Chrysalix Energy Ventures, Growthworks, Business Development Bank of Canada, Braemar Energy Ventures, Entrepreneurs Fund, SET Ventures, Bezos Expeditions, and Cenovus Energy. General

Fusion's work is also funded in part by a grant from Sustainable Development Technology Canada.

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Study on Protective Layer for Severe Accident Conditions for EC6 Reactor Vault Structure

By: H. H. ABRISHAMI[1], R. RICCIUTI[1] and A. KHAN[1] and R. SINGH[1]

[Ed. Note: The following paper was presented at the 34th Annual Canadian Nuclear Society Conference in Toronto, 2013 June 9-12.]

Abstract

The Enhanced CANDU 6® (EC6®[2]) is designed both for the prevention and mitigation of Design Basis Accidents (DBAs) as well as Beyond Design Basis Accidents (BDBAs). The foremost objective, in accordance with the safety goals specified in the CNSC Regulatory Document (RD-337) [1], is to prevent the occurrence of any accident that could jeopardize nuclear safety, and, if an accident should occur, to limit the radiological releases resulting from the accident and minimize the impact on nearby communities.

During a postulated severe core accident, Molten Core-Concrete Interaction (MCCI) may occur when molten core debris breaches the calandria vessel and contacts concrete surfaces, whereby the thermal and chemical properties of the melt contribute to the potential degradation of the concrete. The earliest phase of MCCI is characterized by very-high-temperature molten metal and oxide pouring from the calandria vessel and settling as a pool on the concrete surfaces of the vault floor. The molten material can result in spalling or fragmentation of the concrete near where the corium first contacts the concrete. As the corium settles on the concrete surface, the melt begins to react chemically with the concrete through the penetrating cracks and fragments produced on the initial contact, generating various gases including carbon monoxide and combustible hydrogen.

In order to control and mitigate MCCI, a protective layer (refractory material) with suitable material properties and sufficient thickness was proposed to protect the reactor vault concrete floor. To further enhance vault floor protection and mitigate the conditions under severe accidents a special concrete composition in the upper layer of the vault floor concrete is to be provided in case the refractory material is breached. This special concrete should minimize the generation of various gases including combustible hydrogen and carbon monoxide during MCCI.

As a part of research and development program an experimental study has been proposed to qualify refractory material to meet the CNSC requirements. This paper presents the outcome of this research study.

1. Introduction

During a postulated severe core accident, Molten Core-Concrete Interaction (MCCI) may occur wh molten core debris breaches the calandria vessel a contacts steel liner andconcrete surfaces, whereby t thermal and chemical properties of the melt contr ute to the potential degradation of the concrete. T earliest phase of MCCI is characterized by very-hi temperature molten metal and oxide pouring from t calandria vessel and settling as a pool on the concr surfaces of the vault floor. The molten material c result in spalling or fragmentation of the concrete n where the corium first contacts the concrete. As t corium settles on the concrete surface, the melt beg to react chemically with the concrete through the p etrating cracks and fragments produced on the init contact, generating various gases including carb monoxide and combustible hydrogen. The phenome described apply to the reference design.

Obviously, the ideal objective of using refract material is to protect concrete, however, in reality refractory material will slow the rate of molten c penetration to concrete. This is an additional desi feature in our severe accident management strategy accordance with the defense in depth philosophy.

The Enhanced CANDU 6 (EC6®) is designed both the prevention and mitigation of Design Basis Accide (DBAs) as well as Beyond Design Basis Accide (BDBAs). The foremost objective, in accordance w the safety goals specified in the CNSC Regulat Document (RD-337) [1], is to prevent the occurrence any accident that could jeopardize nuclear safety, a if an accident should occur, to limit the radiologi releases resulting from the accident and minimize impact on nearby communities.

2. CNSC Requirements and Expectations

CNSC Regulatory Document RD-337 [1] conta numerous requirements related to prevention and m igation of severe accidents. The highest level requ ments, against which the adequacy of the design

1 Candu Energy Inc., Mississauga, Ontario, Canada.

2 EC6® (Enhanced CANDU 6®) is a registered trademark of At Energy of Canada Limited (AECL), used under license by C Energy Inc.

measured, are the Safety Goals (4.2.4), the requirements for Accident Mitigation and Management (4.2.4), and the containment performance requirement (7.3.4). Safety goals have been established by the CNSC in RD-337.

As per RD-337 [1] the containment is an integral part of the defence in depth concept associated with its severe core damage prevention and mitigation philosophy. Clause 7.3.4 defines the following requirement for containment performance:

> *"Containment maintains its role as a leak-tight barrier for a period that allows sufficient time for the implementation of off-site emergency procedures following the onset of core damage. Containment also prevents uncontrolled releases of radioactivity after this period."*

The containment performance requirement is intended to ensure that the containment structure can withstand the loads associated with severe accident challenges, and that the potential for radioactive releases from the containment is minimized.

3. EC6 Strategy for MCCI

The Enhanced CANDU 6® (EC6) design consists of an appropriate combination of preventative and mitigative features which prevent uncontrolled radioactive releases during a severe accident, including a severe core damage (SCD) accident. A severe core damage accident results from an initiating event (or combination of events) followed by a series of failures of mitigating actions (including operator actions), resulting in extensive physical damage to the core such that the fuel bundles and channels would be disabled either by mechanical fracture or by melting. As a result, core coolability is compromised. For EC6, a severe accident is defined as having more than one fuel channel fail under accident conditions.

The EC6 includes a number of complementary design features for defence in depth against unlikely severe accidents involving failure of the calandria vessel including protective layer (refractory material). The primary defense is In-Vessel Retention (IVR) and this phenomenon occurs if IVR fails. The protective layer slows the rate at which the corium penetrates through the floor and delays generation of non-condensable gases that would be generated due to MCCI, which would also contribute to containment pressurization. A protective layer on the floor of the calandria vault resists the extremely high temperatures of the corium discharged into the calandria vault, minimizing generation of non-condensable gasses due to concrete-corium interaction (CCI), and prolongs the available time between onset of the event and challenge to the containment structure due to overpressure or a potential melt-through breech.

4. Experiences from Other Nuclear Power Plant Design Features

This section provides the design features of NPP vendors to control/mitigate MCCI during severe accidents. The design philosophy with respect to severe accident given by GE-Hitachi Nuclear Energy for ESBWR [2], Westinghouse Electric Company LLC for AP 1000 [3], and AREVA NP Inc. for US EPR [4] are described below. Among the above design features, only US EPR used protective layer and sacrificial concrete in its design to provide a stage of temporary melt retention.

4.1 ESBWR Design Philosophy

The ESBWR is designed to minimize the effects of direct containment heat, ex-vessel steam explosions, and core-concrete interaction. The ESBWR containment is designed to a higher ultimate pressure than conventional BWRs. The Basemat internal Melt Arrest Coolability (BiMAC) device is designed to prevent core-concrete interactions (see Fig.1). During the severe accident, BiMAC device is intended to provide coolability and eliminates the uncertainty of ex-vessel debris coolability and core- concrete interaction gas generation. The lower drywell floor is designed with sufficient floor space to enhance debris spreading, and also contains the BiMAC device to protect the containment liner and basemat. The debris bed cooling limits basemat penetration, radiated heat and non-condensable (not easily condensed by cooling) gas generation due to core-concrete interaction. The core debris coolability analysis shows that BiMAC device is effective in containing the potential core melt releases from the Reactor Pressure Vessel (RPV) in a manner that assures long-term coolability and stabilization of the resulting debris. Therefore, the possibility of corium-concrete interaction is negligible.

The BiMAC device provides an engineered method to assure heat transfer between a core debris bed and cooling water in the lower drywell during some severe accident scenarios. Waiting to flood the lower drywell until after the introduction of core material minimizes the potential for energetic fuel- coolant interaction. Covering core debris with water provides scrubbing of fission products released from the debris and cools the corium, thus limiting off-site dose and potential core-concrete interaction.

The BiMAC device provides additional assurance of debris bed cooling by providing engineered pathways for water flow through the debris bed. BiMAC failure could occur if no water is supplied. The BiMAC device is not safety-related.

The BiMAC function has been developed to a conceptual level, with several design details that are not yet

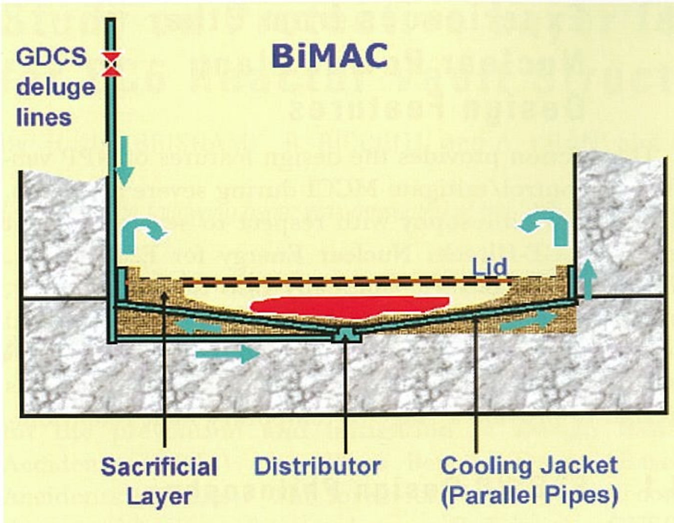

Figure 1: BiMAC System in ESBWR

finalized. These details are needed to justify the target failure probability of less than 1.0 x 10^{-3}.

BiMAC plays an important role in mitigating core melt scenarios.

4.2 AP 1000 Design Philosophy

The AP1000 design incorporates ERVC (External Reactor Vessel Cooling) as a strategy for retaining molten core debris in-vessel in severe accidents. The objective of ERVC is to remove sufficient heat from the vessel exterior surface so that the thermal and structural loads on the vessel (from the core debris which has relocated to the lower head) does not lead to failure of the vessel. By maintaining RPV (Reactor Pressure Vessel) integrity, the potential for large releases due to ex-vessel severe accident phenomena (i.e., ex-vessel Fuel-Coolant Interactions (FCIs), and Core-Concrete Interactions (CCIs)) is eliminated.

The AP1000 reactor cavity design incorporates features generally consistent with the Electric Power Research Institute's (EPRI) Utility Requirements Document (URD) guidance, including the following:

- a cavity floor area and sump curb that provides for debris spreading without debris ingression into the reactor cavity sump
- a manually actuated reactor cavity flood system that would cover the core debris with water and maintain long-term debris coolability
- a minimum 0.85-m (2.8-ft) layer of concrete to protect the embedded containment shell, with an additional 1.8 m (6 ft) of concrete below the liner elevation

The enhanced capability to retain a molten core in-vessel, in conjunction with these design features, results in a low expected frequency of basemat melt-through in the AP1000.

Compared to other advanced light-water reactors (ALWRs), the AP1000 ex-vessel debris bed is deeper a the concrete basemat is thinner. The AP1000 desi does not impose any restrictions on the type of concre that can be used for the containment basemat and t reactor cavity walls. Although these factors tend increase the severity of basemat erosion, analyses usi the MELTSPREAD and Modular Accident Analy Program (MAAP) codes indicate that in the event unabated CCI, containment basemat penetration containment overpressurization will not occur un after 2 days, regardless of concrete composition. Fo limestone basemat, which maximizes noncondensal gas generation and minimizes concrete ablation, ba mat penetration would occur after about 3 days follo ing the onset of core damage. Containment pressu will not reach the applicant's Service Level C estima (728.8 kPa (91 psig)) until even later. Use of basal concrete, which maximizes concrete ablation and mi mizes noncondensable gas generation, would redu the time of basemat melt-through to about 2 days, b containment pressure would not reach Service Level until much later. Thus, in the event that core deb is not retained in vessel, the AP1000 design provid adequate protection against early containment failu and large releases resulting from CCIs.

4.3 AREVA US EPR Design Philosophy

A depiction of the U.S. EPR Reactor Building is p vided in Figure 2. The reactor cavity utilizes a com nation of sacrificial concrete and a protective layer refractory material to provide a stage of tempora melt retention. The melt plug and gate are locat in the reactor cavity and support the melt retenti concept by providing a pre-defined failure location. T melt discharge channel utilizes a steel duct lined w refractory material to direct the conditioned melt fr the reactor cavity to the lateral spreading compa ment. The spreading area consists of a dedicated co ing structure lined with sacrificial concrete to prom stabilization of molten core debris.

Although the limestone common sand (LCS) a siliceous concrete would be able to meet the object of sufficient stability and mechanical properties, comparison to siliceous concrete, LCS concrete l the drawback of releasing significantly more non-c densable gas, particularly CO2, which would result an increased pressure in the containment. Therefo in view of the low gas content objective, LCS concr was rejected and siliceous concrete selected as the b material. The sacrificial layer consists of a 19.7 (500 mm) layer of siliceous concrete with high ir oxide content. In view of low gas content, Iron-ox contributes favourably to oxidizing Zr and U.

The melt discharge channel consists of a steel str ture that is embedded within the structural concr of the containment. The bottom, side walls and top

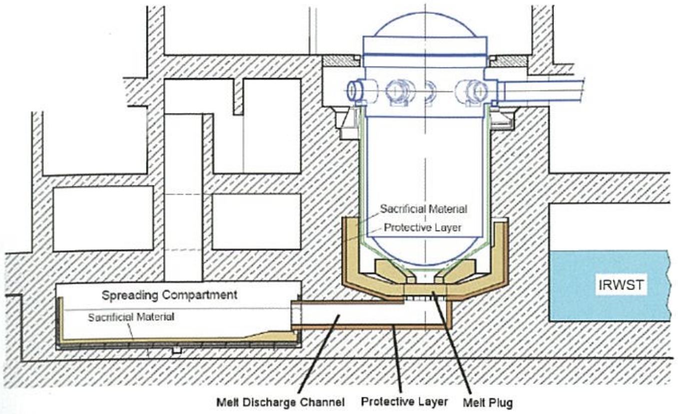

Figure 2: Core Melt Stabilization System (U.S. EPR)

this structure are layered with refractory material. This protective layer consists of zirconia bricks which have a low thermal conductivity and greater mechanical strength than concrete.

The spreading area consists of an approximately 1872 ft^2 (170 m^2) horizontal concrete surface over which the molten core debris can be dispersed. Spreading increases the surface-to-volume ratio of the molten core debris to ensure fast and effective stabilization via subsequent cooling.

5. Proposed Refractory Material for EC6 Reactor Vault

A 300 mm thickness of refractory material is proposed to be placed on the top of the calandria vault steel liner. Refractory material selected for the protective layer is expected to maintain integrity (thermal stability) and have low thermal conductivity, high

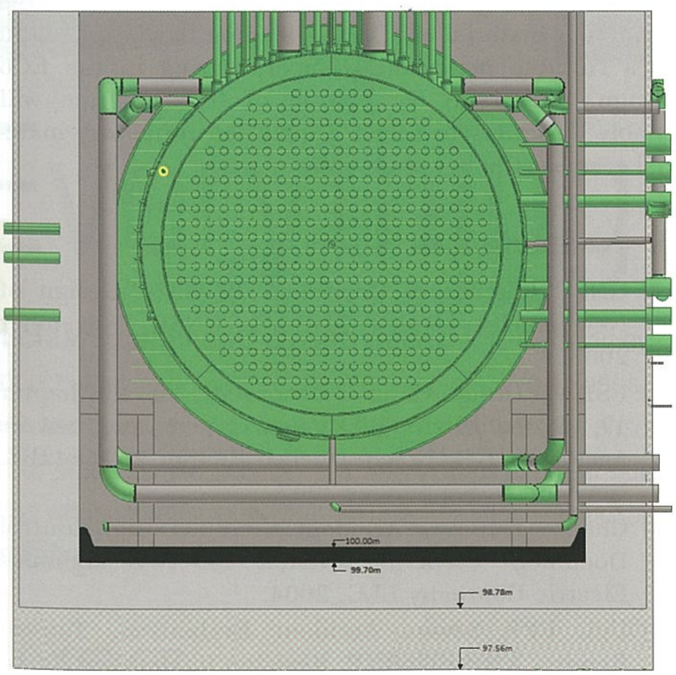

Figure 3: Design layout for refractory material

specific heat and density in order to minimize heat transfer to the reactor vault concrete floor.

6.1 Characteristics of the Refractory Material

The term refractory refers to the quality of a material to retain its strength at high temperatures. ASTM C71 defines refractories as "non-metallic" materials having those chemical and physical properties that made them applicable for structures, or as components of systems, that are exposed to environments above 1000°F (538°C). Refractory materials are used in linings for furnaces, kilns, incinerators and reactors. They are also used to make crucibles. Refractory materials are used extensively in the metal industries, along with glass melting and other heat treatment operations.

Refractory materials must be chemically and physically stable at high temperatures. Depending on the operating environment, they need to be resistant to thermal shock, be chemically inert, and/or have specific values of thermal conductivity and of the coefficient of thermal expansion.

Obviously refractory material may lose the strength during MCCI. However, the refractory material is not load bearing and that the special concrete below it can handle all the loads at high temperature. The refractory material is not a load bearing material and pipe supports cannot penetrate through the refractory to the concrete surface. Thus pipe supports cannot be supported from the floor of the Calandria vault with a refractory cover.

The oxides of aluminum (alumina), silicon (silica) and magnesium (magnesia) are the most important materials used in the manufacturing of refractories. Another oxide usually found in refractories is the oxide of calcium (lime). Fireclays are also widely used in the manufacture of refractories.

The refractory material must be capable of being cast in the field for the depth and extent required without cracking or otherwise losing its effectiveness in workability, curing and finishing.

6.2 Acceptance Criteria for Selecting Refractory Materials

As a basic criterion there are three major parameters with respect to the selecting refractory materials. The selected refractory material shall meet the following criteria:

- Maximize melting temperature of refractory material with sufficient margin of safety for corium temperature > 2400°C;
- Minimize heat transfer to the reactor vault concrete floor and therefore appropriate thermophysical

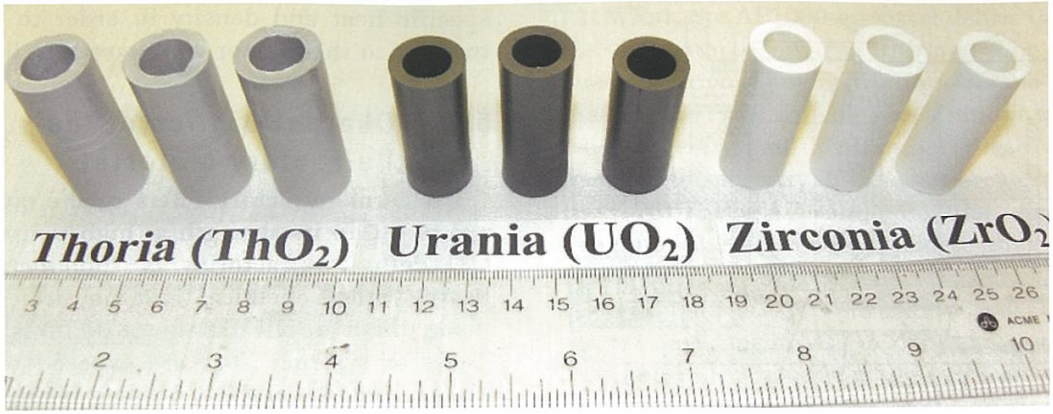

Figure 4: EC6 Refractory material candidates for R&D experiments

properties such as thermal conductivity, specific heat and density; and

- Minimize chemical reaction of refractory material with molten core.

Refractory materials for use a protective layer in the calandria vault floor must be chemically and physically stable at high temperatures and resistant to degradation from radiation exposure. In addition, the refractory material should not have negative impact on the containment response in the long term.

In order to meet the above acceptance criteria, several refractory material candidates were studied and investigated. Among the material candidates, the ones with higher ranking evaluation were selected for experimental R&D program.

7. R&D Program

An R&D program is being undertaken to select a suitable refractory material that can meet the acceptance criteria specified above. The program involves experimental tests to select a suitable refractory material layer which protects the reactor vault concrete floor in the event of severe accident. This research program is near completion. Three promising refractory material candidates, Thoria, Urania, and Zirconia (see Figure 4), are being tested. Successful completion of the program will enable designers to select a qualified refractory material to meet the design requirements.

8. Summary and Conclusions

The Enhanced CANDU 6® (EC6) design consists of an appropriate combination of preventative and mitigative features which prevent uncontrolled radioactive releases during a severe accident, including a severe core damage (SCD) accident.

In addition to a number of complementary features, in order to control and mitigate MCCI, a protective layer (refractory material) with suitable material properties and sufficient thickness was proposed to protect the reactor vault concrete floor. To further enhan vault floor protection and improve containment p formance under severe accidents a special concre composition in the upper layer of the vault floor cc crete is to be provided in case the refractory mater is breached. This special concrete should minimi the generation of various gases including combustil hydrogen and carbon monoxide during MCCI.

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An R&D program is being undertaken to test th refractory material candidates leading to the selecti of a suitable material for incorporating in the E design. Successful completion of the program v enable designers to select a qualified refractory ma rial to meet the design requirements.

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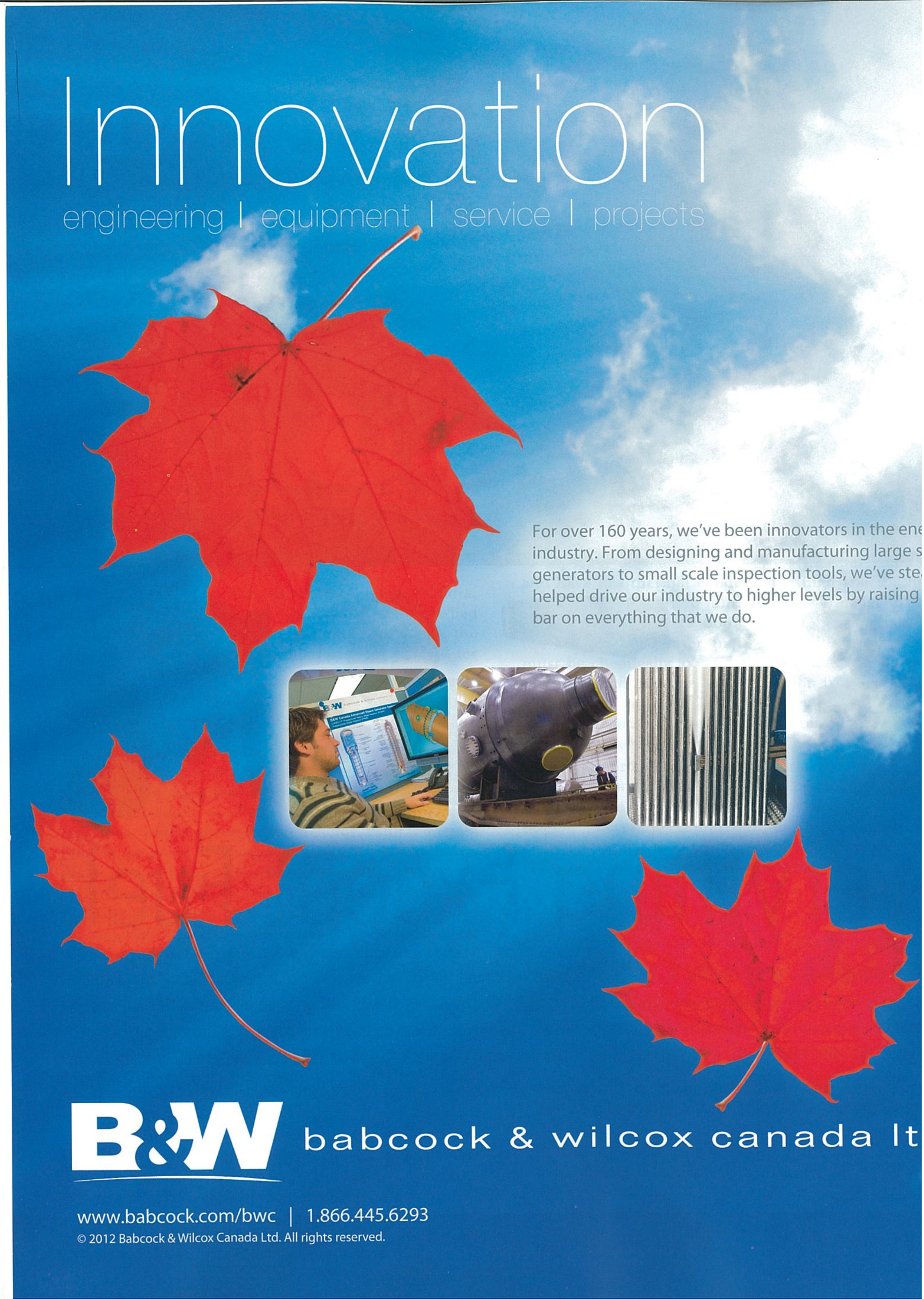
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Taking the Mystery Out of Nuclear Technology at the McMaster Nuclear Reactor

By: CURTIS MCEWAN

In an old parody of Jeopardy that appeared on the show *Cheers* in 1990, ``know-it-all`` character Cliff Clavin answers the final Jeopardy clue of "Archibald Leach, Bernard Schwartz, and Lucille LeSueur" with the clever but unfortunately incorrect response: "Who are three people that have never been in my kitchen?" When looking at the main sources currently exploited for energy production in Canada: coal, natural gas, wind, solar, and uranium, I can't help but think of uranium as the odd one out. After all, if "Uranium" were the final Jeopardy clue facing Cliff Clavin, his (partially) correct response could have been "What is one energy source that hasn't been in my household?"

Nuclear technology, despite the numerous benefits it offers to society, is not something that most people encounter in their daily lives. Coal was widely used for home heating in the not too distant past (and still is in many parts of the world), natural gas is extensively used for heating and cooking, and solar powered calculators have become so commonplace that they can be found in any dollar store (where everything now ironically costs $1.25). The only claim to fame that nuclear has in the household are the americium smoke detectors that sit largely unnoticed on the ceiling and the only regular exposure most have to nuclear comes from what they see on the news which, as many of us in the industry know, doesn't typically portray nuclear in a very positive light. It is thus no surprise that nuclear power has earned a rather unfavourable view in the eyes of many. Without experiencing the benefits on a regular basis, it is easy to forget them when confronted day after day with (often sensationalized descriptions of) the drawbacks.

Anti-nuclear sentiments were greatly heightened after the disaster at Fukushima, causing widespread protests calling for an end to nuclear power. It is interesting to compare the results of Fukushima to those of the Deepwater Horizon oil spill which occurred in the Gulf of Mexico in 2010, killing 11 workers and injuring 17 more. Both events led to large scale contamination with a similar economic impact and both raised health concerns about food contamination. However an interesting difference occurred in the resulting backlash of these events. In the case of the Deepwater Horizon spill, the majority of criticism was directed towards British Petroleum. However relatively little criticism was directed towards offshore drilling or the collection of oil in general. After all this is certainly not the first time that oil has been spilled or that people have been killed on an oil platform so why weren't there large scale protests for an end to oil production? Because oil is a product that is recognized as necessary to society. Planes, trains, and automobiles that we see and use on a regular basis require oil. Interestingly though, in countries like France, the United States or even Germany (before Fukushima) that use nuclear power, one could argue that nuclear power is also necessary to society. Since nuclear is the only large scale power generation option that doesn't contribute to the release of greenhouse gases (GHGs), removing nuclear almost certainly means an increase in GHGs and air pollution if coal is used as a substitute. However since people do not see these benefits of nuclear power in their daily lives in the same way they see the benefits of oil, it is easy to lose sight of them amongst the drawbacks emphasized in the media.

As a tour guide for the McMaster Nuclear Reactor (MNR), I have had the pleasure of welcoming hundreds of guests into the facility. For most it is the first (and perhaps only) experience they ever have of a real nuclear laboratory. I have found that while the majority of people are well aware that radiation can be dangerous, few actually know what radiation is or why it can pose a health risk. Guests are often surprised to know that they receive radiation constantly from natural sources and that in fact a short plane ride gives a significantly higher radiation dose than they receive during the reactor tour. Some are also surprised to find out that the risks posed by radiation to workers are significantly lower than the risks we face every day from things like driving, fires, falls, and drowning. Guests are shown how the cancer-treating medical isotope I-125 is produced in the reactor as well as how neutrons produced by the reactor are used to check for defects in turbine blades destined for use in aircraft engines: two important benefits of nuclear technology. While this information is all readily available on the MNR website, the personal experience of actually seeing a real core or being able to watch medical isotopes being made creates much stronger memories. Things like radiation become less mysterious and guests are able to see with their own eyes the benefits of nuclear technology the way we, as nuclear scientists and engineers, see them every day.


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Opinion

Ontario's IESO prefers Enhanced CANDU 6 over AP1000 for New Build at Darlington

By: DON JONES

The Independent Electricity System Operator (IESO) prefers the Enhanced CANDU 6 (EC6) over the Westinghouse AP1000 for new build at Darlington. Well, that's the inference anyway.

On page 6 of the IESO's written submission to the Ontario Power Authority's (OPA) 2005 December 9 Supply Mix Advice Report to the Minister of Energy (MOE), Volume 5 - Submissions and Presentations Received, it states:

"To bring supply and demand into balance under Unutilized Baseload Generation (UBG) conditions, baseload generation must be shutdown. For example, if a nuclear unit is unable to perform power reductions it will be shutdown, typically resulting in a 48 hour "poison" outage. Such shutdowns, which assist with low demand concerns, can adversely impact the ability to meet demand during subsequent peak periods until the unit(s) return to service. ***Any consideration of nuclear generation additions should examine the ability of the different nuclear options to reduce power under UBG conditions, with preference going to those technologies which can better accommodate this requirement".*** *(author's emphasis)*

Note that the IESO now uses the term "Surplus Baseload Generation" (SBG) instead of "Unutilized Baseload Generation" (UBG). Since the EC6 is much more flexible than the AP1000 (reference 1) it is clear that the IESO preference would be the EC6 for new build at Darlington. Bruce Power's eight units have already demonstrated what even a limited amount of flexibility can achieve, so much so that they are classified as "flexible nuclear" by the IESO (reference 2). The EC6 will have much more steam bypass capacity than the Bruce units and in addition will be able to do reactor manoeuvring when necessary.

The IESO requirement for more flexibility in future capacity additions to the Ontario grid appears regularly in its "18-Month Outlook" series, for example:

"The existing coal fleet, though running at vastly reduced levels from previous years, provides the IESO with desirable flexibility, such as quick ramping and operating reserve, under all market conditions. As Ontario's coal-fired generation is shut down over the next two years, its associated flexibility will be lost. Therefore, future capacity additions should also possess this flexibility to help facilitate the management of maintenance outages, provide effective ramp capability, supply of operating reserve and even provide regulation when necessary".

The EC6 can meet these requirements (reference 1).

The OPA's 2005 December 9 Supply Mix Advice Report to the MOE, Supply Mix Summary, Part 1.1, page 3, states:

"Planning supply mix would be simple if a single source were superior to others in all areas - environmental impact, reliability and costs - and could meet equally well the needs of base, intermediate and peak load. The reality is that no such single resource exists - a combination of resources and technologies is needed, and tradeoffs and synergies among them must be considered".

This false premise is also being promoted by the Canadian Nuclear Society, the Canadian Nuclear Association, and others that should know better and resulted in the government's 2010 Long-Term Energy Plan (LTEP) restricting nuclear to 50 percent of generation because of perceived nuclear inflexibility. On the contrary flexible nuclear can provide reliable base, intermediate, and peak load if necessary, with no emissions at stable and competitive cost (reference 3). Candu Energy Inc. has stated that the Enhanced CANDU 6 has "flexible load capabilities" (reference 4). France gets 75 to 80 percent of its electricity from its flexible nuclear plants and its electricity prices are among the lowest in Europe. France has achieved this with nuclear units that are much less flexible than the EC6. New nuclear build should not stop at the 12,000 MW in the government's LTEP. Much more nuclear capacity must be built (references 5 and 6). The future is with nuclear and hydro, not with frackgas and wind, though with climate change even hydro is not a sure thing. Unlike frackgas a nuclear energy supply is almost inexhaustible and will be available for thousands of years. Other countries can only wish for Ontario's nuclear and hydro infrastructure and potential.

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*Editor's Note: This article also appears as item 30**

** see http://thedonjonesarticles.wordpress.com/articles/*

GENERAL news

(Compiled by Fred Boyd from open sources)

Hearing for Bruce DGR Underway

The hearing by the Joint Review Panel (JRP) on the proposed Deep Geologic Repository (DGR) began its public meetings in Kincardine, Ontario on September 16, 2013 and is scheduled to run until October 12, 2013.

The JRP was appointed in January 2013 jointly by the Minister of the Environment, Peter Kent and the President of the Canadian Nuclear Safety Commission, Michael Binder.

Panel members are: Dr. Stella Swanson, president of Swanson Environmental Strategies Ltd.; Dr. James Archibald, professor at Queens University; and Dr. Gunter Mucke, retired professor from Dalhousie University.

The proposed repository is for low and intermediate radiological waste which has been accumulating at Ontario nuclear generating station sites for many years. The radioactive waste facility is operated by Ontario Power Generation although it is on the site leased to Bruce Power.

The hearings are being webcast through the CNSC website.

Point Lepreau Update

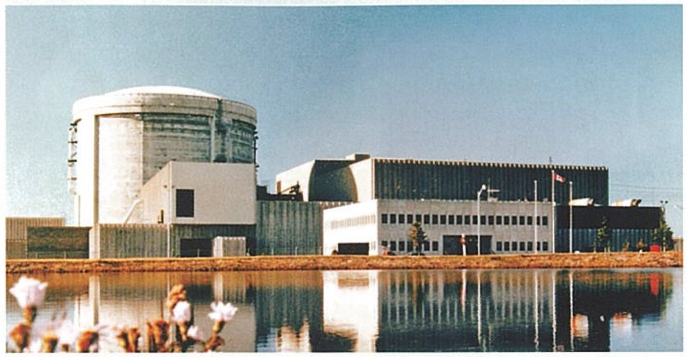
The net capacity factor of the Point Lepreau Generating Station for August 2013 was 93 per cent, New Brunswick Power reported in early September. This matched the company's target for the month.

For the month of August, Point Lepreau produced about 49 per cent of the total net generation from NB Power generating stations.

During a regular plant inspection on Aug. 30, one of the hangers supporting piping on the main steam supply on the non-nuclear side of the plant was found to be damaged. As a result, the Point Lepreau team made the decision to reduce reactor power from 95 per cent to 90 per cent, which reduced vibration levels. Vibrations are currently higher than normal because of the station being in three-valve configuration.

The hanger has been repaired as part of ongoing maintenance and the company is now preparing to replace additional hangers of the same style and operating condition.

Preparations are on track for a two-week outage, scheduled to begin Oct. 18, to repair the plant's fourth steam valve.



"This short outage will allow Point Lepreau to return to 100 per cent power, remain at that level for the New Brunswick winter-heating season and ensure we can provide cost-effective, reliable power to our customers," said Granville. "We budgeted and planned for this type of equipment challenge when forecasting the first year of operation after refurbishment, so the outage will not have an impact on rates to NB Power customers."

Over the next few weeks, there will be work done on lines that connect New Brunswick with the United States as part of upgrades to the New England Power Grid and the Maine Power Reliability Program. There is a possibility that the New Brunswick System Operator may request that Point Lepreau reduce its power level to support the stability of the NB electrical grid if the second interconnection is lost unexpectedly (for example, due to lightning or an equipment failure.

The two new turbine rotors from Siemans will be transported from Saint John Harbour to the Point Lepreau Generating Station this fall. Siemens, which has the lead role in transporting them to Point Lepreau, is working with NB Power, transportation experts, emergency response organizations, and local and provincial government agencies. The dates for transport have not yet been confirmed.

Cigar Lake Start-Up Delayed until 2014

On 09 September 2013Cameco corporation announced that production from the Cigar Lake uranium mine in northern Saskatchewan has been put back until early 2014 due to additional work on underground ore handling equipment. Modifications are also required at Areva's nearby McClean Lake mill before the ore can be processed.

At Cigar Lake, the innovative jetboring mining method loosens the ore with jets of high-pressure water.

Cameco, which operates Cigar Lake, had planned to begin production in the summer of 2013. However, Cameco has now announced that, with construction of the mine already 97% complete and commissioning of the mining systems underway, it does not expect ore production to begin until during the first quarter of 2014. The delay, it said, was due to unspecified problems with the ore handling facilities.

Ore from the mine is to be processed through a toll-milling agreement at Areva's McClean Lake mill. Areva has told Cameco that additional modifications are required at McClean Lake and that the mill will not be ready to start processing Cigar Lake ore until mid-2014.

Cigar Lake is the world's second largest high-grade uranium deposit, with grades that are 100 times the world average. The orebody is being frozen prior to mining to improve ground conditions, prevent water inflow and improve radiation protection. The ore will be removed by a jet boring system, using water under high pressure to carve out cavities in the orebody and the resulting ore slurry collected through pipes. This will be taken to underground grinding and thickening circuits and then pumped to surface as slurry, which will be loaded into special containers for the 70 kilometre journey by road to McClean Lake.

CNSC Awards a Doctoral Scholarship for Research in Nuclear Forensics Analysis

On September 4, 2013, the Canadian Nuclear Safety Commission (CNSC) announced that Ms. Madison Sellers has been awarded a CNSC-funded scholarship for a research project in the field of nuclear engineering, focusing on nuclear forensics analysis. Ms. Sellers is a doctoral student in the Departm of Chemistry and Chemical Engineering at the Rc Military College of Canada in Kingston, Ontario. ! will receive an annual scholarship of $35,000, fo maximum of three years.

The award is for a project that will examine improve Canada's nuclear forensics analysis ca bilities, through the development of new analyt techniques and research methods for special nucl materials. The research will aim to improve a syst for rapid and non-destructive characterization of s cial nuclear materials.

Nuclear forensics analysis is a developing discipli which aims to identify and characterize nuclear m rials or radioactive sources recovered from either capture of unused materials, or from the detonatio a device containing radioactive isotopes. Work in discipline also provides clues on and/or traces to b the origins of the materials or sources, to ultima improve physical protection measures or diversion

Collaborators for this project include the Royal Milit College of Canada, Defence Research and Developm Canada, the Department of National Defence, and U.S.-based Los Alamos National Laboratory.

In celebrating its 65th anniversary in 2011, CNSC established a doctoral scholarship to supp students in pursuit of advancements in the nucl field. The scholarship is awarded to one docto student from a pool of qualified candidates, and associated with the Natural Sciences and Engineer Research Council of Canada's (NSERC) post-gradu scholarship competition. Eligible candidates must of outstanding academic merit and in the process conducting research related to the nuclear field, Canadian post-secondary institution.

Fukushima – Government to Deal with Contaminated Wate

In early September, 2013, the Nuclear Emerge Response Headquarters of the Japanese governm announced its basic policy for tackling the cont inated-water issue at TEPCO's Fukushima Dai Nuclear Power Station.

It includes the establishment of an inter-ministe Council for contaminated water and decommission issues, as well as financial support for moving forw with the installation of frozen-soil shielding walls the land side of the facility.

Prime Minister Shinzo Abe, who serves as the h of the Response Headquarters, said that the gov ment would step forward to identify potential ri and adopt preventive and multi-layered measures go beyond the "follow-up measures" of the past.

Considerable technical difficulties are anticipa involved in both constructing impermeable walls (using the so-called "frozen soil" method) on the land side and developing high-performing multi-nuclide removal equipment.

The government will promote the launch of the two projects as early as possible through financial assistance, including the use of reserve funds, on the order of about (USD320 million)) and (USD150, million), respectively.

As part of a set of drastic measures to deal with the increasing amount of contaminated water the operation of the shielding walls on the land side will be targeted for the period April 2014 to March 2015

A new inter-ministerial Council for contaminated water issues and decommissioning will be set up under the Nuclear Emergency Response Headquarters, with cabinet members from relevant ministries serving as members. That Council will develop policies on decommissioning and contaminated-water measures. It will also manage work schedules, the dissemination of information for domestic and foreign audiences, and the implementation of measures to prevent damage caused by fear and misinformation.

An intergovernmental liaison office will be created near the Fukushima Daiichi NPS, staffed permanently by members of various governmental offices. The aim of the office will be to boost the ability of the government to respond to various situations as the need arises.

Fukushima Contaminated Water

The Japanese Atomic Industry Forum (JAIF) has posted, on its English website, two concise pages with interesting illustrations that help explain the current problem of contaminated water at the damaged Fukushima Daiichi plant.

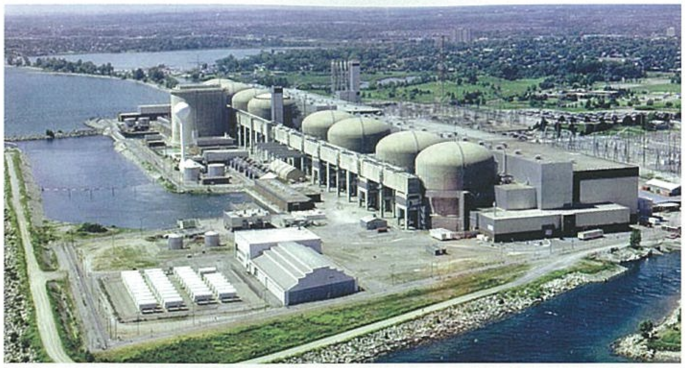
It is titled *"Current situations and measures against contaminated water of Fukushima Daiichi"*.

Their website is: http://www.jaif.or.jp/english/news_images/pdf/ENGNEWS01_1379638552P.pdf

CNSC Renews Pickering Operating Licence

The Canadian Nuclear Safety Commission (CNSC) has renewed Ontario Power Generation Inc.'s (OPG) power reactor operating licence for the Pickering Nuclear Generating Station (NGS). The licence will be valid from September 1, 2013 until August 31, 2018.

In making its decision, the Commission considered information presented at public hearings held February 20, 2103 in Ottawa, Ontario and May 29-31, 2013 in Pickering, Ontario. During the public hearing, the Commission received and considered submissions from OPG and 136 intervenors, as well as CNSC staff's recommendations.



The licence includes a regulatory hold point that prohibits the operation of the Pickering B NGS beyond 210,000 effective full power hours. The Commission will consider OPG's request to remove this regulatory hold point in a future proceeding of the Commission with public participation.

The Commission directs OPG to provide the following, before the removal of the hold point can be approved:

- the revised probabilistic safety assessment (PSA) for Pickering A that meets the requirements of CNSC Regulatory Standard S-294, *Probabilistic Safety Assessment for Nuclear Power Plants*;
- an updated PSA for both Pickering A and Pickering B that takes into account the enhancements required under the CNSC Fukushima Action Plan; and
- a whole-site PSA or a methodology for a whole-site PSA, specific to the Pickering NGS site.

The Commission also directs OPG to ensure the production of an emergency management public information document, to be distributed to all households in the Pickering area, summarizing the integrated emergency response plan of all involved organizations, including all key roles and responsibilities. This document is expected to be produced by the end of June 2014.

CNSC Seeks Input on Amendments to the Radiation Protection Regulations

The Canadian Nuclear Safety Commission (CNSC) is asking the public to provide their comments on Discussion Paper DIS-13-01, proposals to amend the *Radiation Protection Regulations*. The Regulations protect the health and safety of workers and the public by placing limits on radiation doses, and by requiring all CNSC licensees to implement radiation protection programs.

The discussion paper proposes amendments to existing sections of the Regulations, and offers new requirements for radiation detection and measurement instrumentation, and responsibility for radiation protection. These amendments would harmonize the Regulations with updated international standards.

They would also clarify requirements and address gaps identified in light of the nuclear incident at the Fukushima Daiichi nuclear power plant in Japan.

To review and comment on the document, visit the DIS-13-01 Web page. Submissions are requested by December 9, 2013. Comments submitted, including names and affiliations, will be made public.

Bruce Power Replacing Turbine Rotors

Bruce Power is replacing the turbine generator rotors at the recently refurbished units 2 and 3 of the Bruce A nuclear power plant.

Six low-pressure turbine generator rotors - each weighing some 62 tonnes - have been delivered via barges to the Bruce A plant. They will be installed in units 2 and 3 during future scheduled outages.

Bruce Power said that the new turbines will add 40 years of life to the generators in the units. Replacement rotors were recently installed in units 1 and 4.

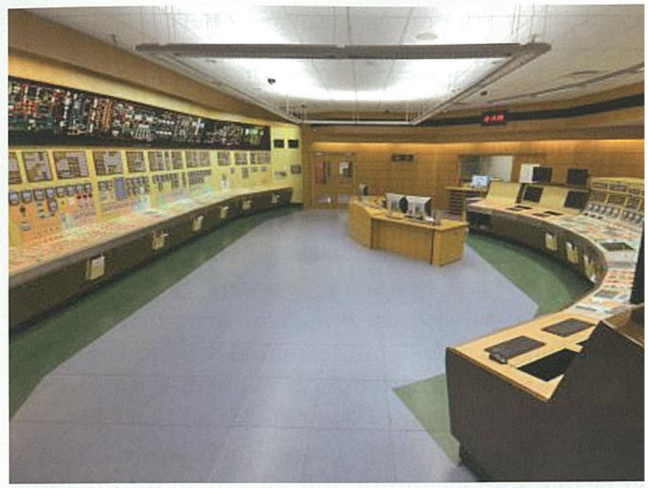
The turbine hall of Bruce A unit 2 (Image: Bruce Power)

Canadian Simulators for South Africa

Montreal based L-3 MAPPS (an advertiser in the CNS Bulletin) has commissioned the second state-of-the-art operator training simulator for South Africa's Koeberg nuclear power plant.

The work has been carried on from contracts signed in 2009. Koeberg's legacy simulator was refurbished in two phases. The first included installation of L-3's Orchid simulation platform, remodelling of the balance of plant process loop, simulation of new steam turbine controllers and was completed in time to allow operators to be pre-trained for changes to the plant itself in late 2010. This was followed by a second phase, which saw all the remaining plant models upgraded.

The second full-scope simulator, which entered service in August 2013, replicates the plant's main



Koeberg's second simulator (Image: J Lagerwald/L-3 MAP

control room and emergency control facility driver a compact modular input-output system.

Koeberg operator training manager Christo Lomb said that plant operator Eskom was pleased with b the L-3 MAPPS technology and the collabora between the two companies, working together to m sure the new simulators were ready concurrently v a new training centre at the site.

Michael Chatlani, vice president of marketing sales for L-3 MAPPS Power Systems and Simulat said the company was "extremely pleased" with its formance on the Koeberg project and looked forw to working to support Eskom "for years to come."

NEA Issues Extensive Report Fukushima

The Nuclear Energy Agency of the Organiza for Economic Cooperation and Development has released a 69 page report on the Fukushima accid with emphasis on international response.

The report is the work of three NEA committe Committee on Nuclear Regulatory Affairs (CNI Committee on the Safety of Nuclear Installati (CSNI) and the Committee on Radiation Protec and Public Health (CRPPH).

The report entitled *The Fukushima Daiichi Nuc Power Plant Accident: OECD/NEA Nuclear Sa Response and Lessons Learnt* outlines internat al efforts to strengthen nuclear regulation, sa research and radiological protection in the post-Fu shima context. It also highlights key messages and sons learnt, notably as related to assurance of sa shared responsibilities, human and organisational tors, defence-in-depth, stakeholder engagement, c communication and emergency preparedness.

An electronic version is available on the OEC NEA website.

CNS news

CNS Intervenes in Hearings

As reported in the June 2013 issue of the Bulletin, the Canadian Nuclear Society officially intervened, on May 29, 2013, in the hearing of the Canadian Nuclear Safety Commission on the renewal of the Operating Licence for the Pickering Nuclear Generating Station.

Subsequently, the CNS Council decided to intervene in two more hearings – the Ontario government's Long Time Energy Plan review and the Joint Environmental Hearing on the proposed Deep Geologic Repository at the Bruce Power site.

The introductory oral presentation by then president John Roberts for the Pickering hearing was printed in the June 2013 issue of the Bulletin. The written submission has been posted on the CNS website.

The submission to the Ontario LTEP has also been posted on the CNS website and is printed below.

For the DGR hearing the CNS submission was scheduled to be heard September 17. It will also be posted on the CNS website.

The Future of Electricity Supply in Ontario

The key to Ontario's strong and resilient economy over the last century has been bold decision-making on the energy file. In the electricity sector this has involved not just long-term forecasting and planning, but decisions to embrace new technologies that offer significant benefits to the people of Ontario – whether it be cost, reliability, cleanliness, or resource availability.

The best example of this foresight is Ontario's fleet of nuclear power reactors, which has benefitted Ontarians with clean, safe, and reliable baseload electricity for over fifty years, and today supplies about half the electricity consumed in the province. Through a unique partnership of federal, provincial, and private-sector interests, Ontario pioneered the CANDU reactor technology that leads the world today in fuel efficiency and safety.

A reliable electricity grid is one based upon a diverse suite of technologies in strategic locations, planned with priority given to cost, reliability, natural resources, environmental impact, and dispatchability (i.e., capability of being employed when needed). These planning decisions are not easy, and must increasingly balance social expectations with technical merits.

For example, the decision by the Ontario government to invest in nuclear technology in the 1950s was not a simple one, and it is not simple today. Significant capital is needed, along with a relatively long planning horizon, and public outreach must be thoroughly embraced as this is probably the technology option that Ontario citizens know the least about.

The pay-off for making this bold decision has been enormous: nuclear-generated electricity has reliably underpinned Ontario's economy for half a century, with low emissions during its entire fuel cycle, a domestic low-cost fuel supply, a waste stream that is easily managed in both the short and long terms, and a safety record that surpasses that of any other commercial energy technology. The presence of the nuclear fleet in Ontario has provided stability for electricity rates in the province, and provided a foundation for the development of non-dispatchable renewable technology like wind and solar.

The CNS is concerned that the suggestion of slowing the pace of nuclear refurbishment or new-build in Ontario may compromise the province's capability to provide low-cost, low-emission electricity. This situation arises due to the relatively long timeframe required for these major projects. It is therefore important that any strategy of nuclear deferral take into account the environmental cost associated with increased reliance on renewable and fossil power. Moreover, it should be made clear in public documents that increased reliance upon less reliable, non-dispatchable technologies, like wind and solar, does mean increased use of fossil fuels to offset the supply shortfall.

The Ontario government is encouraged to continue to make bold decisions regarding long-term electricity supply, which must include a significant contribution from nuclear technology if economic stability, environmental responsibility, and high-tech, cutting-edge jobs are goals for the province under its stewardship.

Saving Your Documents

The University of Ontario Institute of Technology (better known as just UOIT) has added an Archive to its library and is inviting submissions.

Pamela Drayson, UOIT Librarian, is enthusiastic about making UOIT the principle archive of Canadian engineering associations and societies. Over the past two years the UOIT Library has become the official archives for the Engineering Institute of Canada and the Canadian Society for Mechanical Engineering.

The CNS has agreed in principle to take advantage of this offer but, because of more pressing problems, has not yet passed any material to UOIT.

Now Ms. Drayson is inviting individual engineers who have archival material (which is no longer proprietary) to forward them to her. While they need to be sorted they do not need to be catalogued. In fact, Ms. Drayson emphasizes that they are experts in that activity.

So, if you have kept reports or other documents that would provide some insight into the history of nuclear engineering in Canada contact her, at pamela.drayson@uoit.ca or telphone 905-721-8668 ext 2348.

Cataloguing Handbook Posted to Website

One of the outcomes of the AECL/CNS History Project [1] was the production of a Handbook for cataloguing documents in a standard manner, in accordance with contemporary practice. The Handbook prescribes the use of a spreadsheet to capture the relevant information associated with a document (metadata) thus forming a searchable database and facilitating the transfer of information.

The objective of the History Project is to ensure that the accomplishments of nuclear science in Canada are not forgotten and ultimately lost, by capturing it in an orderly fashion for preservation and study.

As CNS members may have documents they might wish to catalogue, the Handbook has been poste the CNS website at http://www.cns-snc.ca and wil found under the History section as a .pdf file.

If you have documents relating to the early day nuclear science in Canada, particularly the 1942-1 period, then download the Handbook and creat catalogue. If you wish assistance with your catal ing activity, please contact Jim Arsenault.

[1] Arsenault, James E. "The History Project, NRC Record 1942–1952." CNS Bulletin, Vol. 33, 4, p.41-42, December 2012.

Help run the CNS

Next year is still a few months away and the ne CNS elections even further.

However, John Roberts, who, as CNS Pa President, is responsible for obtaining nomin tions for CNS Council, the Society's governir body, is anxious to get more members to consid standing for membership on Council.

If you think you might be interested, or know someone whom you think would be a good cand date, contact John, who will provide backgrour information.

His e-mail address is: johngroberts@roger blackberry.net

News from Branches

(The following article is drawn from the report by Branch Affairs chair Syed Zaidi to CNS Council for its meeting on August 30, 2013. Most Branches are dormant in the summer.)

ALBERTA Branch – Duane Pendergast

Proposal for a "CNS Western Branch"

Members of the Alberta Branch met with CNS president John Roberts in Calgary on May 23, 2013, hosted by Jason Donev at University of Calgary. Duane Pendergast, Chair, spoke to the need to refocus Branch initiatives to reflect a long term emphasis on educational initiatives and to consider the role of the CNS in other provinces. To achieve that end an ad hoc Committee was proposed to study a Branch organization structured to make the best use of member skills to help accomplish that goal and to consider expanding geographic coverage to other provinces. Jason Donev chaired the committee.

The committee met by teleconference on July 17, with members from Saskatchewan and Alberta Syed Zaidi in attendance. The concept of a merger unanimously supported by members present and se al volunteered to serve on the executive. An action placed on Duane Pendergast to contact CNS mem affiliated with the Alberta and Saskatchewan Bran for feedback on a proposal to merge. Member f back supported the initiative, including a sugges to include other western provinces and territorie form a "CNS Western Branch". More volunteers the executive were also solicited, and forthcoming

Consequently a new "CNS Western Branch' proposed which includes the present Alberta Saskatchewan Branches as well as British Colum the Yukon and the Northwest Territories. The in volunteer executive structure for the new Branch lows, until such time as the Branch defines new r and/or holds elections to fill defined positions.

The formal proposal, including the proposed execu was approved by Council at its August 30.2013 meet

CNS Western Branch Executives

Position	Member/ Affiliation/Resume
Chair	**Jason Donev**, Ph.D., University of Washington, 2003/Professor, University of Calgary, Alberta, Physics and Astronomy Department /He studies how people learn science and teaches about energy issues, especially nuclear power.
Vice Chair	**Matthew Dalzell**, M.Sc. University of Saskatchewan, 2007/Sylvia Fedoruk Canadian Centre for Nuclear Innovation, Saskatchewan/Science communicator, educator and strategist. Previously with Canadian Light Source and an officer in the Royal Canadian Navy Reserve.
Secretary	**Cody Crewson**, M.Sc., University of Saskatchewan., 2013/ Saskatchewan Cancer Agency/ Currently working on an equipment design project. Interests include how we teach physics in interesting and/or engaging ways.
Treasurer	**Duane Pendergast**, Ph.D., New Mexico State University, 1970, P.Eng. FCNS/retired to Lethbridge, Alberta, from AECL safety and licensing studies/Duane, mechanical engineer, notes that energy is the essence of life on this planet. The search for energy must go on.
Membership Coordinator	**Robert L. Varty**, Ph.D., University of Toronto, 1980, P.Eng./Consultant in Engineering Science, Edmonton, Alberta/ Interest includes fluid flow, heat transfer, nuclear radiation, and scientific software. Skills include technical writing and public speaking. Joined CNS in 1981.
Education Coordinator	**Shaun Ward**, B.Ed., B. A/Sc., University of Lethbridge, 1972/ Retired Lethbridge College Mathematics Instructor /Shaun served as a Lethbridge alderman for 20 years. He is keenly interested in municipal, provincial, and national energy strategies.
Members at Large	**Tamara Yankovich**, Ph.D.in Radioecology, Trent University, 2005/ Saskatchewan Research Council moving to IAEA/Addresses issues around modeling, monitoring and assessment of radionuclides in the environment.
	Duane Bratt, Ph.D., University of Alberta, 1996/Professor, Political Science, Mount Royal University/ Duane has written several books on Canada's nuclear policy, Alberta media routinely contact him on political and nuclear issues.
	Ron Matthews, PhD, Geophysics, Imperial College, University of London,1976/ Retired to Victoria, B.C. in 2011 from Managing Director for Cameco, Australia/ Interests include aspects of earth sciences in the uranium mining industry, including geophysical methods, project management, community relations, working with aboriginal groups, and nuclear education.
	Denise Chartrand, M.A. in Conflict Analysis and Management, Royal Roads University, 2013/ Project Coordinator, NatPro, Calgary/ Denise is of Metis descent and is passionate about working with aboriginal communities, industry, government and environmental leaders to provide a safe space to dialogue about sustainable resource development.

CHALK RIVER Branch – Ruxandra Dranga & Bruce Wilkin

Speakers:

- The CNS Chalk River Branch presented four presentations in cooperation with the Deep River Science Academy, as follows:
  - o **July 11** – Jeremy Whitlock – "Splitting Atoms – Canadian Style"
  - o **July 18** – Peter Lang – "Safe Flight, A pilot's approach to safety and risk management in the conduct of an overseas airline flight"
  - o **July 25** – Bill Diamond – "Accelerator Production of Medical Isotopes"
  - o **August 1** – Morgan Brown – "The Fukushima Reactor Accident. What Happened and the Canadian Response"

All talks were very well attended, with 35-45 people (including the 24 DRSA students). The students were very keen to learn more about the nuclear industry, asking a number of key questions and engaging the speakers in very interesting conversations.

- On **August 16th**, the CNS Chalk River Branch also hosted Dr. John Roberts, Nuclear Fellow at the Dalton Nuclear Institute at the University of Manchester, UK. (and immediate Past President of the CNS). His talk, titled *"The Nuclear Situation in* *the UK: How we got here, where we are, and where we might be going"* was organized as a joint CNS CRB and AECL R&D Seminar, at Chalk River Labs. The seminar provided a brief history of nuclear industry in UK, and discussed the current plans to advance their industry. After the talk, Ruxandra Dranga and Jeremy Whitlock joined Dr. Roberts for a tour of some of the facilities at CRL, and during discussions with various departments at AECL regarding potential collaborations.

- The AGM for the Chalk River Branch will be scheduled for the beginning of October.

Education and Outreach:

- On **August 10th**, the Deep River Science Academy hosted their 2013 Graduation Ceremony. Ruxandra Dranga attended the ceremony on behalf of the CNS Chalk River Branch and presented the two Canadian Nuclear Society Awards for Excellence in Innovation to the recipients (see picture at right). The recipients this year were:
  1. Bill Jia
  2. Anmol Jawandha

Other Initiatives:

- Ruxandra Dranga and Tracy Pearce will be working closely with Syed Zaidi to help improve the communication between branches, and facilitate quarterly teleconferences between key branch members (e.g., Branch Chair and Treasurer). These meetings are meant for discussions and brainstorming on how to increase the efficiency of branch operations and improve communication between branches.

Deep River Science Academy students Bil Jia a Anmol Jawandha pose with Chalk River Branch co-chair Ruxandra Dranga with their certificat for the CAN Award for Excellence and Innovati

NEW BRUNSWICK Branch – Mark McIntyre (Acting)

The NB Branch is putting together our Fall 2 program. No additional activity since the last rep

OTTAWA Branch – Mike Taylor

The Ottawa Branch has not yet resumed activ after the Summer.

New IAEA Publication

Operating Experience with Nuclear Power Stations in Member States in 2012

2013 Edition (CD-ROM)

Operating Experience

This CD-ROM contains the 44th edition of the IAEA's series of annual reports on operating experience with nuclear power plants in Member States. It is a direct output from the IAEA's Power Reactor Information System (PRIS) and contains information on electricity production and overall performance of individual plants during 2012. In addition to annual information, the report contains a historical summary of performance during the lifetime of individual plants and figures illustrating worldwide performance of the nuclear industry. The CD-ROM contains also an overview of design characteristics and dashboards (not included into the web version) of all operating nuclear power plants worldwide.

STI/PUB/1620; 2013; ISBN 978-92-0-194310-1, English, 55.00 Euro

Electronic version can be found:

http://www-pub.iaea.org/books/IAEABooks/10597/Operating-Experience-with-Nuclear-Power-Stations-in-Member-States-in-2012-2013-Edition-CD-ROM

Women in Nuclear CANADA

WiN-Canada is part of Women in Nuclear, a world-wide association of women working professionally in various fields of nuclear energy and radiation applications. The organization has been working to emphasize and support the role that women can and do have in addressing the general public's concerns about nuclear energy and the application of radiation and nuclear technology. WiN-Canada also works to provide a platform for women to succeed in the industry through initiatives such as mentoring, networking, and personal development opportunities.

Executive Director

Founded in 2004, the organization has seen strong growth both in membership and in recognition. The Annual Conference is a cornerstone event that sees 200 members come together to learn and share technical and career focused information.

The Executive Director has a great deal of both responsibility and opportunity. Reporting to the Board of Directors the Executive Director's chief responsibilities are the day-to-day running of the organization including developing and implementing plans and initiatives that support and advance the strategic directions and governance policies established by the Board, as well as implementing a compelling vision and strategy and leading the organization to build on past successes and realize its full potential. The Executive Director will act as a liaison to a wide variety of stakeholders including the Board, local chapters and industry's top-level management, manage event planning and drive all marketing and communication activities.

This role is rich with the opportunity to increase the presence of this unique professional group and provide an even stronger voice for the nuclear industry in Canada.

While a background in the industry is not required, it would be helpful as would previous experience in not-for-profit leadership, marketing and community development and the ability to travel within Canada and internationally.

Interested candidates should forward their resumes and cover letters to women.in.nuclear.canada@gmail.com by Friday, October 11, 2013.

www.wincanada.org

Obituary

Samuel Graham (Sam) Horton, an early superintendent of NPD, Canada's first nuclear power plant, died in Mississauga, Ontario, on July 26, 2013, at the age of 80.

Born in Saskatoon, Saskatchewan on December 8, 1932, Sam grew up in Leney, Saskatchewan. He graduated from the University of Saskatchewan in 1953, with an engineering physics degree and then obtained a Masters of Management Science from the University of Waterloo.

Sam joined the newly created Civilian Atomic Power Department (CAPD) of Canadian General Electric Company as a member of the CAPD commissioning team. He joined what was then Ontario Hydro and was one of the small crew that started NPD on April 11, 1962.

He quickly rose through the ranks of Ontario Hydro's nuclear program, going on to hold various senior executive positions covering Engineering, Supply & Services, Human Resources, and Aboriginal Affairs. He was a leader in technology, innovation and social responsibility, who often fought against the status quo to ensure fairness and justice. In particular, Sam was a strong advocate on aboriginal affairs and work place equity.

He remained active in the area of aboriginal affairs following his retirement.

Sam was predeceased by by his first wife, of 40 years, Sybil, with whom he had four children and survived by his second wife Carol and his two step-daughters.

A service of remembrance was held July 30, 2013 at Christ Church, Mississauga.

10TH INTERNATIONAL CONFERENCE ON CANDU® MAINTENANCE

Revamping the Technical Strength of Our Industry

Metro Toronto Convention Centre, Toronto, Ontario, Canada **May 25-27, 2014**

CALL FOR ABSTRACTS

CMC 2014 – Revamping the Technical Strength of Our Industry

CMC 2014 will bring together subject matter experts from Operating Utilities and Service Providers under the banner of CANDU® Maintenance.

With the objective of revamping the technical strength of our industry, CMC 2014 will focus on the following drivers that achieve and sustain high performance:

- **Policy and Vision,**
- **People and Skills,**
- **Processes and Tools, and**
- **Plant Equipment and Reliability.**

CMC 2014 will focus on future – making use of our past and present experience to meet the Needs and Interests of the Operating Utility (the NIOU concept introduced at CMC 2011). It will provide the ideal environment for open and free exchange of ideas, where industry experts will use past and current experience to identify, define and address tomorrow's challenges and opportunities.

Abstract Submission Deadline: October 4, 2013

Call for Abstracts

The Technical Program Committee invites the submission of abstracts of proposed presentations pertaining to the Technical Focus of the conference and the themes of the Plenary and parallel Technical Sessions.

Submission of full papers is optional, but PowerPoint slide presentations are required for inclusion in the Conference Proceedings.

Technical Focus

Abstract submissions are to address the themes of the four Plenary and parallel Technical Sessions:

Policy & Vision	People & Skills	Processes & Tools	Plant Equipment & Reliability
Regulatory Affairs	Succession Planning	Work Management	Nuclear & Support Systems
Standards	Training & Mentoring	Engineering Change Control	Primary Circuit Components
Business Strategies	Human Resources	Supply Chain Strategies	Secondary Circuit Components
Leadership	Human Performance	Tooling & Robotics	Electrical and I&C
Management Oversight	Staffing Strategies	Information Technology	Chemistry Control
Visions of the Future	Personnel Safety	Radiation Protection	Water and Air Systems
Refurbishment Strategies	Resource Modeling	Nuclear Safety	Maintenance Backlog Mgmt
New Nuclear Strategies	Maintenance Facilities	Process Mapping	Equipment Reliability
Continuous Improvement	Knowledge Transfer	Models & Simulations	Steam Generators & Heat Exchangers
Safety Culture	Teamwork	Life Cycle & Aging Mgmt	Valves
Learning Organization	Integrated Maintenance Planning	Obsolescence Mgmt	Pumps & Motors
Independent Verification	Contractor Management	On-Line Diagnostics/Testing	Emergency Water/Air/Power
		Maintenance Fundamentals	Reactor Control

Get engaged: plan to participate as a Speaker, Session Chair or member of the Organizing Team

Abstract Criteria and Submission

Abstract Criteria

Abstracts are to be no more than 300 words in length and submitting presenters must address the following criteria when preparing their abstracts:

1. Address the **Needs and Interests of Operating Utilities** (NIOU).
2. Be **forward looking**, using past & current experience to revamp the technical strengths of our industry.
3. **Identify, define and resolve** issues challenging the industry.
4. Address industry concerns around '**Policy & Vision**', '**People & Skills**', '**Processes & Tools**', and '**Plant Equipment & Reliability**'.
5. Strong preference will be given to Service Providers who **collaborate with utilities** as co-authors on submissions to demonstrate the value of their work to the industry.

These themes are broken down into potential subject areas in the table provided on the reverse side of this handout.

Abstract Submission and Presenter Notification

Details of how abstracts are to be formatted and submitted are on the conference website **www.cmc2014.cns-snc.ca**

Click on the link to CMC 2014, then go to the 'Presenters' Information' tab.

Completed abstracts are to be submitted online to: **https://www.softconf.com/d/cmc2014/**

All abstracts will be formally reviewed and assessed by the Technical Program Committee and presenters will be advised of the results of the Committee's review by **November 5, 2013**.

Conference Information

CANDU® Course

A CANDU® Course similar to that of CMC 2011 will be provided on Sunday, May 25, 2014 from 9:00 am until 5:00 pm. Details will be posted on the conference website.

Questions and Answers (Q&A)

Questions and answers will be formally documented during sessions for inclusion in the Conference Proceedings CD that registered participants will receive after the conference.

Trade Show

The conference will again include a Trade Show that will facilitate networking between the range of Service Providers and their utility customers. Details are on the conference website.

Sponsorship Opportunities

Conference sponsorship provides increased Corporate profile and visibility as "Leaders of the Industry", and recognition of your company as a supporter of the goals and objectives of the conference. Details are on the conference website.

Important Dates

Abstract Submission Deadline	October 4, 2013
Presenter Notification	November 5, 2013
Early Registration	March 21, 2014
Full Papers (optional) Due for Conference Proceedings	April 21, 2014
Hotel Reservation Cut-off Date	April 24, 2014
CANDU® Course	May 25, 2014
Conference Dates	May 25-27, 2014
Final PowerPoint Presentations (required) Due for Conference Proceedings	June 6, 2014

Registration Fees

Full Conference registration fees include HST and provide participation in the Sunday Welcome Reception, early morning refreshments, morning and afternoon beverage breaks, luncheons and a reception and dinner on Monday evening that includes a guest speaker. Registrations are to be completed online through the link on the conference website.

Full Conference	Early Registration *(paid by **March 21, 2014**)*
CNS Member	$700
Non-Member	$800
Full-time Student Member	$100
Retiree	$250
CANDU® Course Only	
CNS Member for CANDU® Course only	$300
Non-Member for CANDU® Course only	$350
Full-time Student for CANDU® Course only	$100

Hotel Accommodation

The InterContinental Toronto Centre Hotel is the official hotel for the conference and are providing guest rooms for CAD$185.00 (plus applicable taxes) for single/double occupancy. Details are on the conference website and reservations commence May 31, 2013.

Contact

If you have any questions about submission of abstracts, please contact the Conference Administrator:

Elizabeth Muckle-Jeffs
Conference Administrator
The Professional Edge
North America Toll-free: 1-800-868-8776
International: 1-613-732-7068
Email: Elizabeth@theprofessionaledge.com

For all conference details go to:
www.cmc2014.cns-snc.ca *or* **www.cmc2014.org**

Hosted by the Nuclear Operations & Maintenance Division (NOM) of the Canadian Nuclear Society

19th Pacific Basin Nuclear Conference
PBNC-2014
Hyatt Regency Hotel, Vancouver, British Columbia, Canada
2014 August 24-28

Fulfilling the Promise of Nuclear Technology around the Pacific Basin in the 21st Century

PBNC-2014 Vancouver 2014

Call for Papers

PBNC-2014 Vancouver 2014

The Pacific Basin Nuclear Conference (PBNC) was initiated originally as a regional cooperative forum to advance peaceful uses of nuclear energy in the Pacific Basin Region. The first conference was held in Hawaii, USA (PBNC-1976), and the most recent one in Busan, Republic of Korea (PBNC-2012). The Canadian Nuclear Society and the Canadian Nuclear Association are proud to host the 19th Pacific Basin Nuclear Conference (PBNC-2014) in Vancouver, Canada, under the aegis of the Pacific Nuclear Council.

The theme of PBNC-2014 is "Fulfilling the Promise of Nuclear Technology around the Pacific Basin in the 21st Century". It has been established to (i) showcase the advancement of nuclear technology in power generation, health science, and environmental stewardship, (ii) discuss challenges facing nuclear technology, and (iii) highlight future development. The official language of the conference is English. Authors are encouraged to submit papers on any topic in nuclear technology for oral presentation in technical sessions at PBNC-2014. Papers will be organized in 10 technical tracks.

Program Outline

- Welcome Remarks and Opening Plenary
- Daily Plenary Sessions/Panel Discussions
- Daily Technical Parallel Sessions
- International Student Conference
- Closing Session
- Optional Workshops and Tours
- Exhibition
- Guest Program

Key Dates

Abstract Submission (date extended!):	2013 Oct. 31
Notification of Abstract Acceptance:	2013 Nov. 01
Deadline for Draft Paper Submission:	2014 Feb. 28
Comments to Authors:	2014 April 01
Deadline for Final Paper Submission:	2014 June 01
PNBC-2014	2014 Aug. 24

Abstract and Paper Submissions

- Acceptable paper formats: Word document, RTF, PDF
- Abstract for submission should be 150-250 words.
- Full papers should be no more than 12 (8.5"x11") pages including tables, figures and references.

Information on paper submission and templates are available from the conference website at

http://pbnc2014.org/call_for_p.html

Committee:	Chair
International Steering:	Frank Doyle
International Technical Program:	Bill Kupferschmidt
Plenary & Keynote:	Jerry Hopwood & Ron Oberth
Sponsors and Exhibitors:	Doug Burton
Executive Administration:	Ben Rouben

Canadian Nuclear Society® Société Nucléaire Canadienne

Pacific Nuclear Council PNC

NU The Future is NU. Canadian Nuclear Association

19th Pacific Basin Nuclear Conference
PBNC-2014
Hyatt Regency Hotel, Vancouver, British Columbia, Canada
2014 August 24-28

CALL FOR PAPERS - TECHNICAL TRACKS

Track	Typical Technical Topics
1. Enhancing Safety, and Security	**Safety Forum**: perspectives after Fukushima; extreme events; severe accidents; accident management; emergency planning; plant security; human performance; safety culture; stress testing; risk assessment; probabilistic analysis
2. Improving Operation and Maintenance	**Industry and Operators Forum**: economics; maintenance; reliability; inspection; capacity factor; risk assessment; outage reduction; fuel performance; addressing ageing and obsolescence; new developments; reliability enhancement; power uprating; component replacement; supply chain
3. Facilitating Energy Policy and Global Consensus	**Policy Forum**: policy development; energy mix; sustainability; climate change; public acceptance; education; communications; international and regional cooperation; safeguards; proliferation-free fuels
4. Environmental Protection and Waste Management	**Environmental Protection and Waste Management Forum**: designing for environmental protection; assessment of environmental effects; decommissioning and environmental remediation; waste stream management and reduction; progress in repository development; alternative disposal strategies; interim used fuel storage strategies; used fuel recycling and reprocessing; new waste treatment and packaging technologies.
5. Deploying New Reactors and Building to Time	**New Build Forum**: establishing new build program; international collaborations; risk-informed safety regulation; policy; regulation and risk assessment; probabilistic & deterministic risk analysis; addressing life extension and licensing renewal; design and construction; economics and financing; new- site licensing; new developments and designs; Gen-III+ designs/ Gen IV and SMR concepts/ advanced systems and components; passive safety
6. Fuel Cycles	**Fuel Forum**: Uranium and thorium mining, milling, refining, conversion and enrichment; uranium and Thorium fuel manufacturing; fault-tolerant fuel design; open and closed fuel cycle
7. Developing New Technology and Applications	**Technology Forum**: fusion; hydrogen production; advanced reactor physics; modern fuel cycles; recycling and reuse; adopting new materials; efficiency enhancements; Gen IV and SMR concepts; space, mining and military applications; new nuclear codes and standards
8. Addressing Public Concerns about Radiation Impacts	**Public Forum**: experience from Fukushima; social impacts; educating & partnering with public; opinion surveys; radiation protection; Linear-no-threshold issues; radiation health effects; lessons learned; outreach
9. Facing Competitors and Reducing Cost	**Industry Forum**: design and construction; manufacturing and modularity; economics and financing; supply chain assurance; outage management; market and competitive challenges
10. Acquiring Medical and Biological Benefits	**Medical Forum**: medical and biological systems; treatments and protocols; new isotope manufacture; novel accelerators and target development; supply assurance; handling waste streams; economics; international trends; advanced reactor physics; isotope production and use; agricultural applications

CNS Office Has Moved

The official office of the
Canadian Nuclear Society has changed.

It is now:

Canadian Nuclear Society
c/o AMEC NSS Limited
700 University Avenue, 4th Floor
Toronto, ON M5G 1X6

The telephone number and e-mail address remain the same.

Tel. 416-977-7620

E-mail: cns-snc@on.aibn.com

Do not expect to be able to walk into the office unannounced.

The CNS office operates largely through the electronic media. Denise Rouben and Bob O'Sullivan operate largely from home. Accounting is handled by a contractor. The President, Adriaan Buijs and his Executive Committee also work primarily through electronic communication.

The President's e-mail address is: **buijsa@mcmaster.ca**
The e-mail address of the Secretary, Colin Hunt, is: **colin.hunt@rogers.com**

2013 – 2014 CNS Council

The following members were elected to serve on the governing Council of the Canadian Nuclear Society for the 2013 – 2014 term.

Executive

President	Adriaan Buijs
1st Vice-President	Jacques Plourde
2nd Vice-President	Vinod Chugh
Past President	John Roberts
Treasurer	Mohamed Younis
Secretary	Colin Hunt

Members at Large

Parva Alayi	Tracey Pearce
Fred Boyd	Jadranka Popovic
Emily Corcoran	Ben Rouben
Ruxandra Dranga	Nick Sion
Dan Gammage	Ken Smith
Krish Krishnan	Aman Usmani
Laurence Leung	Jeremy Whitlock
Kris Moha	Alex Wolf
Dorin Nichita	Syed Zaidi
Peter Ozemoyan	

The Council members are listed on the CNS website, with photographs and brief description of background.

Special General Meeting Deferred

The Special Meeting of Members originally planned for Sunday, September 15, 2013 has been postponed to Sunday, November 3, 2013.

At the Annual General Meeting of the Membership in Toronto on Sunday, June 9 in Toronto, it was resolved that two items should be postponed to a Special Meeting of Members in September at the venue of the CANDU Fuel Conference in Kingston. Those two items were the adoption of new by-laws consistent with the new Canada Not For Profit Corporations Act, and the tabling of the report of the Auditor.

At the Council meeting of Friday, August 30, Council agreed that the draft by-laws were in need of further revision, thus requiring the Special Meeting to be postponed. Accordingly a new time and location has been set.

Date: **Sunday, November 3, 2013 at 2:30 p.m.**

Location: Renaissance Downtown Hotel (the Skydome Hotel), Blue Jays Room, One Blue Jays Way, Toronto, Ontario, M5V 1J4.

All documentation required for the meeting will be provided to all members in advance.

Calendar

2013

Sept. 15-18 — **12th International Conference on CANDU Fuel**
Kingston, Ontario
website: www.cns-snc.ca

Sept. 29-Oct. 1 — **WiN Canada – 10th Annual Conference**
Best Western, Pembroke, ON
website: www.wincanada.org

Sept. 29-Oct. 2 — **Global 2013 International Nuclear Fuel Cycle Conference**
Salt Lake City, UT, USA
website: www.ans.org

Oct. 27-31 — **Joint International Meeting on Supercomputing in Nuclear Applications and Monte Carlo**
Paris, France
Contact CNS e-mail: cns-snc@on.aibn.com

Oct. 28-30 — **CNS CANDU Technology and Safety Course**
Toronto, ON
website: www.cns-snc.ca

Nov. 10-14 — **American Nuclear Society - Winter Meeting**
Washington, D.C., USA
website: www.ans.org

2014

Feb. 26-28 — **CNA Nuclear Industry Conference and Tradeshow**
Westin Hotel, Ottawa, ON
website: www.cna.ca

Apr. 27-30 — **Canada - China Conference on Advanced Reactor Development**
Niagara Falls, ON
website: www.cns-snc.ca

May 25-27 — **10th International CNS Conference on CANDU Maintenance**
Metro Convention Centre
Toronto, Ontario
website: cns-snc.ca

June 15-19 — **American Nuclear Society - Annual Conference**
Reno, NV, USA
website: www.ans.org

Aug. 24-28 — **19th Pacific Basin Nuclear Conference**
Hyatt Regency Hotel,
Vancouver, BC
website: www.cns-snc.ca

Oct. 26-31 — **Nuclear Plant Chemistry Conference 2014 (NPC-2014)**
Sapporo, Japan
website: www.npc2014.net

Book review

By: DON WILES (retired Carleton University)

"Super Fuel. Thorium, the Green Energy Source for the Future" by Richard Martin

Palgrave MacMillan, 2012.

This book is a presentation praising the proposed Liquid Fuel Thorium Reactor (LFTR), in which the fuel is molten ThF_4. I had heard a radio review with the author of this book and it struck me that he was oversimplifying something, so I bought the book and read it through. I was particularly interested in the nature of these reactors and what were their special safety features. The author is a journalist, but enjoys friendship with and displays strong admiration for friends who are physicists and engineers. (I am not a reactor engineer.)

The book is primarily a sales-pitch, with a lot of history. Some parts of the history are well known, other parts not so, and much of it seemed irrelevant to my intended objectives. Much discussion of the opposing personalities of Admiral Rickover and Alvin Weinberg and of the roles played by many others, most of whose names are familiar. I found later in the book that it became interesting just to read (contrary to what I had expected).

On the matter of technical details, however, the book did not meet my expectations and in some important respects I think it was just incorrect. The most important problem for me dealt with the radioactive waste products. I find it clearly misleading to state that "The long-lived radioactivity of LFTR waste is one ten-thousandth that of a conventional reactor." While it is true that U-233 fission does not produce the transuranic elements, it is also true that the lower fission products (notably Sr-90) are produced in much larger yields. Further, the claim that the radioactivity would be much lower in a few decades rather than a few thousands of years struck me as optimistic. The author seems to ignore Tc-99, I-129, Cs-135, Zr-95 and a number of others. In another place, it seems that the author fails to distinguish between Tc-99m and Tc-99. Apparently, there is to be a side process in which fission products are removed (Xenon can be removed and sold!) but there was no mention of how this is to be done.

Altogether, I find that this book contains interesting history. However, with the omissions mentioned above, I am not sure how much of the science and engineering I would trust.

Everything's Coming Up Trilliums

by JEREMY WHITLOCK

Ah, Nuclear Power, my old friend. Please do come in. Have a seat. Again you've been away too long.

I feel silly coming here Doc.

Now, now, hush. Sooner or later, everyone comes here. Tell me, how are things going?

Well that's just it Doc – on the face of it you might say things are going reasonably well.

Yes, I haven't seen you on CNN for a while. Running smoothly then?

Well, all eighteen reactors in Ontario were running this summer – first time in over fifteen years! And often lately we've seen two-thirds of the province's power come from nuclear fission! Sometimes almost 80%...

Wow, impressive. Like France.

Yeah I guess so. But...

But something's troubling you. What is it?

Well, I can't shake this sense of my own mortality. The feeling that all this could end very soon. I feel like one of those guys wearing the red shirts in Star Trek – you know, like I could buy it before the next commercial and nobody would care.

Interesting. And you feel this way despite basically running Ontario this summer?

But does anyone know that? Or care?

I care.

I pay you to care Doc. Even the Ontario government, though, which you think would give a damn – they don't seem to be too bothered one way or the other.

Now wait a minute. Doesn't the province's 2010 Long-Term Energy Plan call for about the same contribution from you in the foreseeable future?

The LTEP? Oh please – I can see the script now: "unnamed guard in red shirt joins the Away Team on the shuttle..."

What do you mean?

I mean look what they're doing with the LTEP three years later – humming and hawing, wringing their hands, getting ready to throw the Least Voteworthy under the bus.

Ah I see, the LTEP review underway this summer – you feel this is backtracking somewhat?

Backtracking? They're practically putting the phaser in the alien's hand and pointing it at my head.

Well that's really interesting, Nuclear Power, because I've been hearing a lot about this LTEP review lately from your compatriots. It would seem to me that everyone's a little concerned, and I wouldn't say you're being mentioned in any particular – how you say – "red shirt" context...

The others have been here? Even Coal? How's Coal doing?

Oh, you know, dead man walking. Drags himself in here, smokes like a chimney for an hour, coughs up a lung and leaves.

And Hydro?

Mostly stares off into space. Keeps mumbling about being the renewable energy source that everyone forgets about. Sad really. I had to bump him last week so Wind could take his appointment – you've got to take Wind when you can get him.

Ah, Wind... He can't be too worried, surely...?

Interesting case, Wind. A real nervous type, you know? Keeps fidgeting, then falls asleep suddenly in the middle of a session. Then wakes up yelling, and runs out the door, and never books ahead his next appointment – too busy I guess. Never seems to know his own schedule from one day to the next.

What about Natural Gas? Surely he hasn't needed to talk to you...

Oh on the contrary, I see that chap quite a bit. Giggles a lot. Seems to feel that things are looking up. Keeps saying good things about the rest of you – loves renewables, feels bad about Coal but wishes him well, wants to see every reactor in Ontario refurbished...

Hm, I wonder why. Maybe something to do with being the fall-back guy for the rest of us. I bet he's salivating with anticipation.

Well, he does have a sparkle in his eye, that's for sure. But flighty – every now and then he breaks down and complains about feeling guilty. Says that he's not exactly being honest when he calls himself "clean". But then he gets over it and becomes quite anxious – wants the province to make a decision right away, almost like he's afraid people will change their mind.

Or the price of gas will go up.

Ah yes, as a matter of fact he did mention that, and he kept nervously looking at his watch and glancing out the window.

Hey ... should you be telling me all this? What about doctor-patient confidentiality?

Oh please, nobody believes a word you say anyway. I'm safe.

I see. Well listen, the fellow I'm mostly worried about is Conservation...

Conservation! Great guy. That lad's going places. Real go-getter.

You're kidding - You've seen him too?

Well, sort of. He's never shown up. Best patient I've ever had. Pays in full.

So... he's not a real patient?

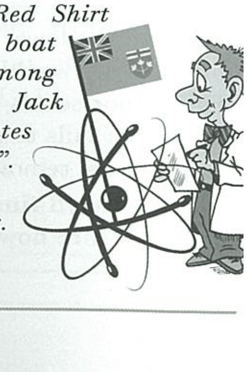
Of course he is. Booked in all next week as a matter of fact. I'm going golfing.

I don't get it.

Neither do I. Listen, forget the Red Shirt thing. I think you're all in the same boat – and in fact you're the sanest one among them. I'd say you're more like a Jack Nicholson, boldly leading the inmates in "One Flew Over the Cuckoo's Nest".

Yeah? How did he make out?

Um... times up. Thanks for coming. Please book again on the way out.



Applying **nuclear science and technology** to the benefit of Canada

For more than 60 years, Atomic Energy of Canada Limited (AECL) has served the nation as Canada's premier nuclear science and technology (S&T) organization. AECL and its laboratories are a strategic element of Canada's national S&T infrastructure as well as its national innovation system.

Through the application of our unique facilities, expertise and experience, we work to ensure that Canada and the world benefit from nuclear science and technology.

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Depuis plus de 60 ans, Énergie atomique du Can limitée (EACL) est au service du Canada à titre de princip organisation en science et technologie (S et T) dans domaine nucléaire. EACL et ses laboratoires constituent élément stratégique de l'infrastructure nationale en S et T Canada et de son système national d'innovation.

Grâce à nos installations uniques et à l'application de no expertise et de notre expérience, nous veillons à ce que Canada et le reste du monde profitent des bienfaits de science et de la technologie nucléaires.

EACL peut aider à faire progresser les projets en innovat de ses partenaires au sein des industries et des universi et est toujours prête à envisager de nouvelles possibilités collaboration.

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