CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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- History: Montreal Lecture No. 8
- Long-Term Management of Used Nuclear Fuel
- Workshop: Supercritical Water-Cooled Reactors
- General News

Successful Restart of the NRU

As you have no doubt heard in the news, the National Research Universal (NRU) reactor is once again harvesting medical isotopes and resuming research and testing of materials and components for the Canadian nuclear industry. (See General News in this edition of the Bulletin.) Given the nature of the repairs this is a remarkable achievement of innovation and dedication to safely supply materials and research that have become critical for the health and prosperity of Canadians.

When the discovery of a heavy water leak was made in May 2009, the extent of the problem was not known. Small leaks of heavy water have occurred in the past and have generally been contained and repaired quickly. In this case, the leak was traced to an area at the bottom of the reactor vessel where there was visible corrosion on the outer wall. The repair time was then estimated to be one month. However, when more detailed inspections were made, it became painfully obvious that a quick return to service was not a possibility. The repair would require removing all of the fuel and heavy water from the vessel, which in itself would take a month to remove 100 rods and transfer them to the cooling pool and another month to put them back. Then the situation worsened.

Other corrosion related "areas of interest" were discovered that had the potential to form a leak. The prudent decision was made to "fix it properly" rather than risk future unplanned shut-downs. Unfortunately, the locations needing repair were not accessible and repair tools were not yet invented. As a result there were further setbacks and AECL took a beating in the media for its inability to provide and commit to a timeline. Imagine trying to do a repair weld to a drain pipe underneath your house where the only access point is the drain hole in your basement! Sometimes we need help because we can't do it ourselves.

In the small town of Dundas, Ontario (near Hamilton) is where that help came from. A high tech robotics company, Liburdi Automation Inc. was contracted by AECL to design, construct and test a special welding tool (shown on the cover page of this edition) that could enter the "floor drain hole" and reach the areas in need of repair. The rest is history.

In hindsight it may have been just as easy to simply replace the aluminum vessel as was done in 1971, in approximately the same timeline as the recent NRU outage. I can't speculate on whether it would have been a cheaper option, but it was an option nonetheless. It was probably not considered at the time the leak was first discovered since the extent of the outage was not known and a vessel would first have to be fabricated. Furthermore, the 1971 outage was planned and the McMaster Nuclear Reactor produced the essential medical isotopes, something that McMaster had offered to do again.

The longer term fate of the NRU is not known and its operating licence expires in October 2011. Indeed the NRU has been running on borrowed time. It was supposed to be shut down permanently in 2005, when the MAPLE reactors would be running to replace the NRU. Unfortunately the MAPLE project encountered some technical difficulties. I have no doubt whatsoever that those technical problems would have been overcome by the talented people at AECL, perhaps with a little help. However, the Harper government ran out of patience and cancelled the MAPLE project, which in my opinion was premature. The government has since declared that it is getting out of the isotope business.

Perhaps a privately held AECL would be better positioned to exploit our talents – it seems a better plan than our tradition of digging stuff out of the ground and selling it abroad. We could buy medical isotopes from foreign entities, but we have proven that we can do much better than that. We need to speak up on the need for a Canadian multi-purpose research reactor ... LOUDLY!

In This Issue

Although there were no major CNS events this summer we do have two meeting reports, one by John Roberts on Uranium 2010, and another by Shane Matte and Laurence Leung on the Joint Workshop on the China Canada Super Critical Water Reactor (CCSC-2010). We are also pleased to include an item of History, "Montreal Lecture No. 8", assembled by Jim Arsenault. We are also pleased to include an article by Neale Hunt of the NWMO on the long-term management of used nuclear fuel.

Our new president, Adriaan Buijs, took the gavel and we have a "Meet the President" item in the CNS News section. There are two technical papers and the usual General News, and Jeremy Whitlock's metaphorical nuclear drinking glass which is apparently "Half Full", in Endpoint, which can be found at the end of this edition of the Bulletin.

Your comments and letters are always welcome!

An active Society

We are now into September, the typical beginning of the working or studying year. The previous two, or perhaps three, months of our short summer is often a time to get away from our normal duties. Not so for the members of the new (2010 – 2011) CNS Council who met in both July and August to plan for the year ahead.

Along with the normal activities of appointing the chair persons for the various Divisions and Committees, Council began early this year in planning for the 2011 Annual Conference, which will be held in Niagara Falls. Frank Doyle, who, by tradition, in his role as 1st VP, is the overall chair for that most important event, decided to begin planning early and has formed the basis of his organization committee. However, if any reader is interested in helping, contact him. As the old saying goes, many hands make the work easier.

Then Council was faced with a possible new and unexpected venture.

At the July meeting Council learned that the Canadian Nuclear Association had decided to cease publishing the Nuclear Canada Yearbook after some thirty years. The CNA representative to CNS Council suggested that CNS might take on the role of publisher.

Being in the role I have I looked into the situation and determined that CNA was quite prepared to transfer the "rights" to the publication and that Colin Hunt and other former members of the CNA staff who had produced the Yearbook over the past several years would be interested in doing it for the CNS.

When the CNS Executive was informed of my findings considerable discussion ensued. However, the members decided to present the case to the full Council. That was done at the August Council meeting, evoking further discussion. While some believed that a Yearbook was primarily an industry publication others felt it served a useful communication function and could enhance the visibility of the Society. Council decided to proceed, on the condition that an acceptable arrangement could be developed with Colin Hunt on behalf of the former CNA staff members. That was achieved in early September and the project is now proceeding.

A busy fall

This fall sees two events sponsored and run by the Society and one international one being held in Canada organized by the CNS. The last mentioned is the first on the calendar – *Nuclear Plant Chemistry 2010* - one of the series of International Conferences on Water Chemistry of Nuclear Reactor Systems, first held in the UK in 1977 as the Bournemouth Conference and held biennially since in various countries. It will be held in Quebec City October 3 – 7, so you still have time to attend.

Then there is the *11th International Conference on CANDU Fuel* in Niagara Falls, October 17 -20. Finally, to round off the busy season, there is the *Technical Meeting on Low-Power Critical Facilities and Small Reactors*. This one has been organized to mark the 50th Anniversary of the ZED-2 test reactor at the Chalk River Laboratories. It will be held in Ottawa, November 1-3.

The nuclear scene

While nuclear power is expanding in much of the world the situation in North America is one of stagnation, with little sign of new units here in Canada or in our neighbour to the south.

New plants are being built throughout Asia, especially China, India and Korea, with many of the smaller countries making concrete plans. The UK is pushing ahead with its large planned program and Russia, along with some eastern European countries is building or planning new units.

The stalemate in the USA and Canada appears to be due to quite different factors. In the USA, the federal government openly supports new nuclear while the utilities, in that great centre of capitalism, are crying for more government aid. In Canada the basic problem appears to be one of ideology at both the federal level and Ontario, with no sign that either is likely to change its position.

Reportedly, many of the companies involved in our nuclear power program are still reasonably busy supporting the major refurbishment at the Bruce station and, to a lesser degree, at Point Lepreau. Bruce, in particular, can see the successful conclusion of the huge refurbishment of units 1 and 2 and is now beginning on units 3 and 4. However, the bungling of the calandria tube replacement at Point Lepreau, has resulted in Hydro Québec deferring the planned refurbishment of Gentilly 2. One could read into the wording of their announcement the possibility that they might change their mind completely if the problem at Point Lepreau is not resolved soon.

All in all, not an encouraging scene.

About the Cover Page Photo

Working in partnership with Liburdi Automation Inc. of Dundas, Ontario, AECL designed and developed the repair tools to conduct the horizontal and vertical repair welds. The design allows technicians to lower the tool into the reactor vessel through the narrow access point. Once the tool is anchored to the bottom of the reactor vessel, technicians extend an 'arm' of the tool to reach the repair site and begin welding. With testing of the tool completed at the vendor's facility, the tools arrive at Chalk River Laboratories for final testing and qualification at the NRU reactor mock-up.

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~ Cover Photo ~

Special welding tool designed and developed by AECL for the difficult repairs to the NRU reactor vessel.

Photo courtesy of AECL

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2010 Canada-China Joint Workshop on SCWR 'A Great Success'

*[**Ed. Note:** This report was prepared for the CNS Bulletin by Shane Matte and Laurence Leung of AECL.]*

Sponsored and organized by Atomic Energy of Canada Limited (AECL) and Natural Resources Canada (NRCan) with the support of Canadian Nuclear Society, the 2nd Canada-China Joint Workshop on Supercritical Water-Cooled Reactors (CCSC-2010) was held at the Courtyard Marriott Downtown Hotel in Toronto this April and welcomed a significant gathering of participants from research organizations and institutions spanning both countries.

"This year's workshop was a great success," said Laurence Leung, Acting Manager, Advanced Concepts and Collaboration. "We were thrilled to host 101 engaged registrants who attended the workshop to exchange knowledge and collaborate around SCWR technology, a considerable increase in attendance and participation from the 1st Workshop in Shanghai in 2008."

The four day workshop, which took place from April 25th to 28th, 2010, was created to provide a forum to discuss advances and issues, share information and promote future collaborations around SCWR technology development. The SCWR is one of the six nuclear energy systems selected for further development by the Generation IV International Forum, a cooperative international endeavour established to carry out research and development of the world's next generation nuclear energy systems.

Acting Director General of OERD of NRCan, Mary Preville, providing the welcoming address.

"Both China and Canada have the infrastructure and the expertise in place to drive SCWR technology forward," noted Leung. "This partnership benefits both countries. Establishing and developing these relationships will help expedite the development of key SCWR technologies while avoiding the duplication of work."

A total of 78 papers were submitted to this year's workshop and 69 papers were accepted for presentation, with a focus on Reactor Core and Fuel Designs; Materials, Chemistry and Corrosion; Thermal-hydraulics and Safety Design; and Balance of Plant. In addition, applications of SCWR for hydrogen production and steam production (oil-sand application) were presented in two separate sessions. Mary Preville, Acting Director General of

Group Photo of CCSC-2010 Participants.

Keynote Speech from AECL Chief Technology Officer, Tony De Vuono.

Keynote Speech from AECL Acting General Manager and Vice President of R&D, Rick Didsbury.

Keynote Speech from NPIC Chief Engineer of the Reactor Engineering Research Division, Yanping Huang.

the Office of Energy Research and Development (OERD) of NRCan provided a warm welcome to participants from Canada and China to the workshop. She highlighted the close relationship between Canada and China in Nuclear Research and Development, and encouraged participants to advance the SCWR technology further.

Workshop organizers were pleased to welcome conference participants from several key nuclear companies from China. All of the Chinese attendees at the Shanghai Workshop (CCSC-2008) were from academic institutes, so the breadth of participants at this year's workshop was very encouraging. "We were really happy to see organizations across China embrace this year's conference, with participants from the Nuclear Power Institute of China (NPIC), the China Institute of Atomic Energy (CIAE), and the State Nuclear Power Technology Corporation (SNPTC) in attendance. That's an important step forward for CCSC."

The workshop featured keynote speakers from AECL, NPIC, SNPTC, and NRCan. AECL Chief Technology Officer, Tony De Vuono, presented the EC6 reactor and ACR designs as well as the natural uranium equivalent (NUE) and thorium fuel developments. Acting General Manager and Vice President of AECL R&D, Rick Didsbury, introduced the key technical advancement in R&D relevant to the CANDU SCWR design.

Chief Engineer of the Reactor Engineering Research Division, Yanping Huang, highlighted the SCWR program at NPIC. He listed more than 140M Chinese Yuan (equivalent to about CDN$22M) of R&D investment for the SCWR from the Chinese government to NPIC since 2009. A schedule was presented supporting /promoting the SCWR design and demonstration (by 2025). Dr. Huang emphasized the need for domestic (in China) and international cooperation and collaboration to implement the project.

R&D Manager, Cong Li, presented the SCWR program in SNPTC of China. He described their SCWR design and identified the collaborative effort between SNPTC and the Chinese academic community in advancing the design and R&D effort.

Acting Program Director of the NRCan Gen IV National Program, Daniel Brady, described the program structure. He emphasized the close interactions between industry, federal laboratories and Canadian universities following the successful launch of a program to engage universities in 2009. He highlighted the benefits of these interactions to universities participating in the program, including enhanced infrastructure, advanced knowledge of SCWR, and education of highly qualified personnel. These benefits are applicable to both nuclear and nonnuclear industries.

After the inspiring keynote speeches, all participants were anxious to start the technical sessions. The program was separated into 18 sessions, each with four presentations on a specific technical subject. All presenters were well-prepared and well-equipped with colourful presentations to enhance conveying their subject knowledge to the attendees. The attendees were equally ready to absorb the new information and advanced technology, and fully engaged in the discussion. Overall, all participants were satisfied with the information given and received at each session.

A workshop banquet was held in the evening of April 27. After two full days of presentations, all participants were looking forward to informal discussions at the social event. Of course, a nice meal and a glass of wine got everybody into the festive mood. Prior to the dinner, Ed Malison of Centerline (Windsor) Limited, one of the workshop sponsors, provided an informative talk on cold-spraying technology, which has found many industrial and military applications. The technology has also been applied to the vessel repair of the NRU reactor at AECL.

Following the workshop and a visit to NRCan's Material Technology Laboratory in Ottawa, a group of 19 Chinese work-

Keynote Speech from SNPTC R&D Manager, Cong Li.

Keynote Speech from Acting Program Director of the NRCan Gen IV National Program, Daniel Brady.

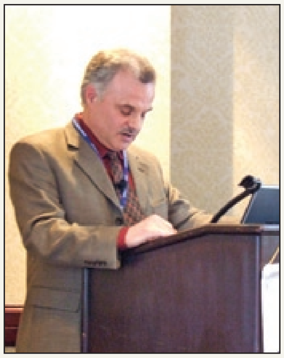
Peter Tremaine of the University of Guelph presenting recent advances in water chemistry for an SCWR.

Wenyue Zheng of the NRCan Material Technology Laboratory participating in the discussion.

shop attendees participated in a full day visit to AECL's Chalk River Laboratories. The visitors were given guided access and insight into a number of different facilities at CRL, including the Advanced CANDU Fuel Development Lab, the Recycle Fuel Fabrication Lab, the Thermalhydraulics Lab, and the MFMI Lab.

"Ultimately, Canada and China are both working towards the same goals," concluded Leung. "This collaboration will move SCWR innovation forward and help shape the future of nuclear technology for both countries."

The CCSC-2010 has successfully brought experts and newcomers from the industry and the academic community closer together to advance SCWR technology with a common goal. All participants enjoyed the opportunity to exchange information, share ideas, and build friendships across the Pacific Ocean. To continue providing the forum for discussion, the 3rd Canada-China Joint Workshop on Supercritical Water-Cooled Reactors (CCSC-2012) has been planned for 2012 in Xi'an, China.



Ed Malison of Centerline (Windsor) Limited presenting the cold-spraying technology at the workshop banquet.

Uranium 2010 draws large attendance

*[**Ed. Note:** This report was prepared for the CNS Bulletin by John Roberts]*

Bill Boyd

Over 5000 delegates assembled in Saskatoon, Saskatchewan, August 15 to 19, 2010 for Uranium 2010, the third International Conference of Uranium. Although most were from Canada there were significant numbers from 26 countries including Australia, France, Russia, USA and Kazakhstan.

The conference was organised by the Canadian Institute of Metallurgy, Mining and Petroleum, It included the 40th Annual Hydrometallurgy Meeting.

Engin Özberk, vice president of Technology and Innovation for Cameco and a CNS member, was the honourary chair of the conference and opened the reception on the Sunday evening.

Speaking in the plenary sessions on Monday morning were: Hon. Bill Boyd, Saskatchewan Minister of Energy and Resources; Gerald Grandey, CEO of Cameco; Roger Alexander, President and CEO, AREVA Canada; Michael Binder, President, Canadian Nuclear Safety Commission; and Galymzhan Pirmatov, Vice-President, Finance, National Atomic Company, "Kazatomprom" JSC, Kazakhstan.

On Tuesday the Hydrometallurgy business luncheon was addressed by Peter Mackinnon, President, University of Saskatchewan.

The conference banquet was addressed by the Hon. Rob Norris, Minister of Advanced Education and Immigration. He was followed by the Hon. David Anderson MP for Cypress Hills – Grasslands.

Very positive remarks were made by all speakers with respect for the quantity of uranium with respect to available, proven deposits, and the future for uranium. It was stated that the as yet undiscovered reserves of uranium bearing ores were expected to be large.

The Saskatchewan economy was stated to be performing well with the uranium industry being a significant contributor. The Saskatchewan government wants to pursue as much "added value" from uranium as possible.

Discussion included the possibility of small reactors. The size of the Saskatchewan electrical grid limited the use of a large reactor for electrical generation. However, should the tar sands in the northwest of the province be developed then a reactor to supply the necessary energy is a real possibility. That being said no speaker would commit to when or where a reactor would be committed. Also discussed was a facility for production of medical radioisotopes along with increased research surrounding uranium and nuclear power.

A number of tours were organized which occurred prior to and following the conference. The tours prior to the conference included the McArthur River mine and the Key Lake processing mill and after the conference the Canadian Lightsource. A course, held prior to the conference, covered all aspects of uranium processing from mineralogy to refining and conversion. All events were well subscribed.

Thanks to John Roberts, CNS 2nd VP, for this report.

IESO - Will Ontario's wind turbine power plants reduce greenhouse gas emissions?

Coal-fired power plants in Ontario are to be phased out by 2014 and are being replaced by natural gas-fired power plants. Wind turbine power plants are being built in the belief that they will reduce the greenhouse gas (GHG) emissions from the gas-fired plants. Dispatchable coal is being replaced by dispatchable gas and not by non-dispatchable wind.

There is some doubt whether the billions of dollars being spent by Ontario's electricity consumers on Ontario's wind turbine power plants, including necessary gas back-up and supporting transmission infrastructure, will result in any appreciable, or even any, reduction in greenhouse gas (GHG) emissions. It is difficult to impossible for the layman to get a handle on this due to the highly complex operation of the grid by the Independent Electricity System Operator (IESO).

Generation supply and demand on the grid has to be kept in balance at all times. The IESO does this by dispatching generators at five minute intervals, not necessarily the same generator, to request that power move up or down. The hydro stations are extremely flexible when available and can quickly respond to dispatching requests. However, they are dependent on precipitation and there can be water management restrictions.

Coal-fired units are less flexible than hydro but more flexible than the Combined Cycle Gas Turbine (CCGT) units that are replacing coal. There are also Simple Cycle Gas Turbine (SCGT) units, much less efficient than CCGTs, which can come on line very quickly to meet peak loads or other eventualities.

Present nuclear units are the least flexible and prefer to operate at steady base load although they are regarded as dispatchable by the IESO.

Wind generation depends on the wind and is not dispatchable. As more wind is installed it will have an impact on the grid in both high and low demand scenarios. Wind is a preferred supplier under present government rules and must be accepted on to the grid when available. When the wind picks up other units on the grid will have to power down to maintain grid balance. If hydro is powered down it would not reduce GHG and other emissions from the gas units. If the CCGTs are powered down there still might not be any significant GHG reductions since the units cannot be completely shutdown. Some will be held in their load dispatching range of around 70 to 100 percent of full power to be available for dispatching, or on hot standby in case the winds drop. A sudden drop in wind would bring on the peaker SCGTs, and hydro if available, until the CCGTs on standby can power up enough to respond to dispatches. Any time gas turbine units operate at part load to accommodate wind turbines, emissions per megawatt hour of generation will increase. Furthermore, there will be wear and tear damage leading to higher maintenance costs.

The more difficult scenario is the case of oversupply, which tends to occur in the spring and fall, overnight and on weekends. This is called Surplus Baseload Generation (SBG). SBG is expected to increase in the future, not helped by unscheduled wind, until an improving economy and growing population increases demand. As wind generation comes on to a grid that already has low demand the gas units are powered down, base load hydro minimized and, if possible, exports are maximized. However, there must be enough flexible hydro and gas available to handle grid load changes and be available in case the wind drops. Eventually, if the wind generation keeps on increasing, the present approach is for selected nuclear units to make one significant power reduction to another constant power level or shutdown completely, and be replaced by more gas, and hydro if available. When a nuclear unit is shutdown it will not be available again for up to three days because of nuclear physics reasons so if demand increases over this period it would have to be met with gas-fired generation. Shutting down nuclear units that produce low cost reliable electricity without GHG emissions and replacing this electricity with higher cost energy from gas and wind makes little economic, technical or environmental sense. Furthermore, shutting down and restarting nuclear units results in wear and tear and puts the grid at risk.

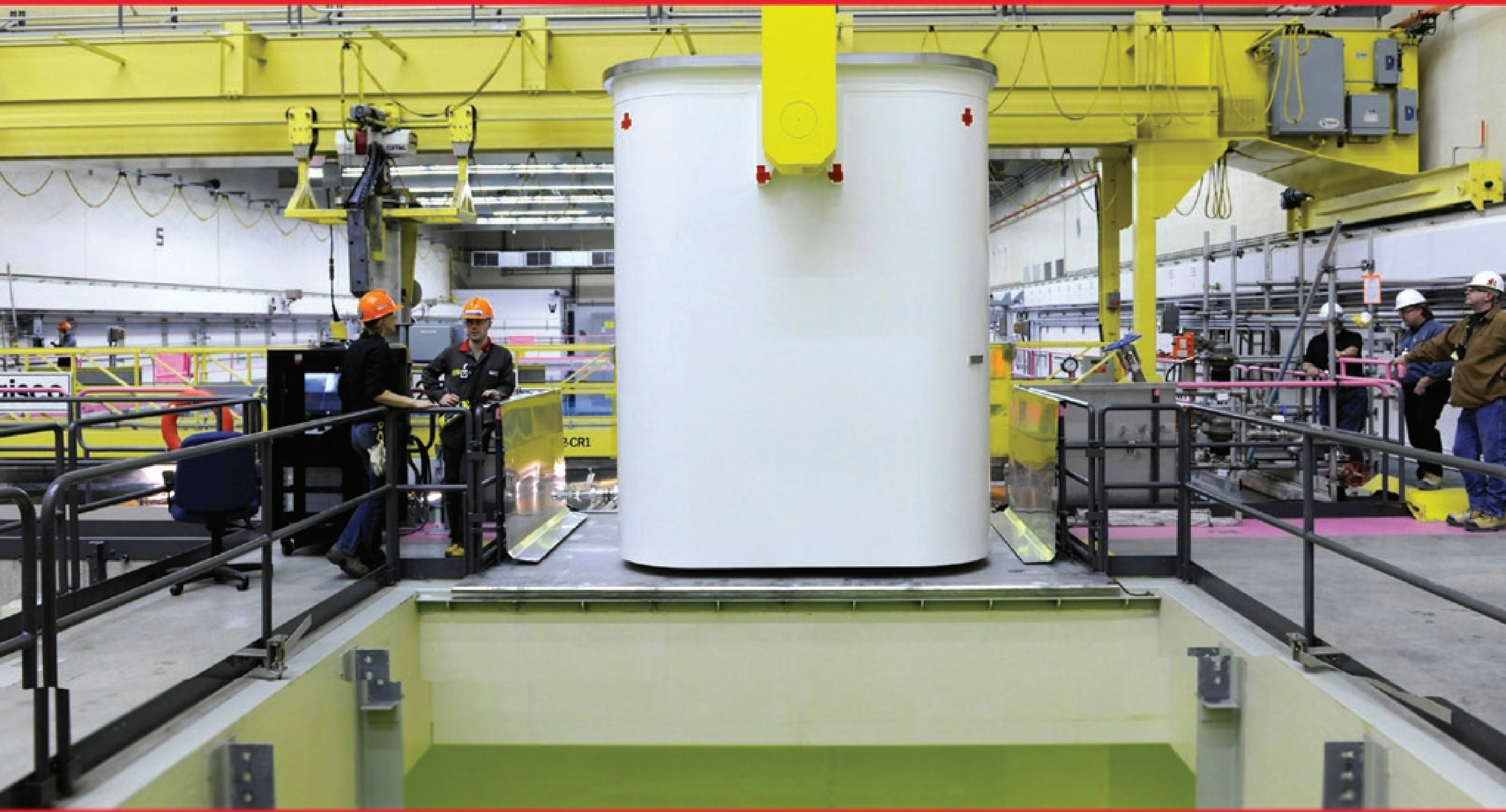
For the newer wind turbine power plants under the Feed-In-Tariff program the IESO is offering financial incentives to the wind operators to shutdown their plants during times of SBG. Under this incentive wind operators would get paid if they shutdown in response to an IESO directive. However, even if wind is shutdown, if the SBG is deep enough nuclear plants would still need to be shutdown, or powered down, with GHG emitting gas-fired plants taking care of load following on the grid. As more controversial shale gas gets into the natural gas supply it raises the question of life cycle GHG emissions. Taken on a life cycle basis GHG emissions from burning shale gas may approach or equal coal. In this case it would have made economic sense to keep operating the coal-fired stations with low sulphur coal and flue gas clean-up until new nuclear became available and skip this monstrously expensive and risky venture with gas and wind.

Now the people at the IESO can see why we are all confused about this gas and wind thing!

Is Ontario making a huge mistake?

Don Jones

*[**Ed. Note:** This is an edited version of Don's full article, which can be read at http://windconcernsontario.wordpress.com/2010/08/23/ieso-will-ontarios-wind-turbine-power-plants-reduce-greenhouse-gas-emissions/#comments. A related article by Don can be read at http://windconcernsontario.wordpress.com/2010/06/08/time-for-the-ontario-government-to-rethink-this-gas-and-wind-thing/.]*



The Long-Term Management of Canada's Used Nuclear Fuel

by Neale Hunt[1]

*[**Ed. Note:** After almost 30 years working for Ontario Hydro, Ontario Power Generation and AMEC-NSS in such areas as thermalhydraulic and containment analysis, trip assessment, quality assurance, best estimate and uncertainty analysis and the MAPLE project, Neale Hunt retired in 2009 to look for new and different challenges. He is currently the Manager of Used Fuel Safety Assessment at the Nuclear Waste Management Organization.]*

When the *Nuclear Fuel Waste Act* was passed by the Government of Canada in 2002 specific responsibilities were assigned to the major owners of nuclear fuel waste. Amongst other things, the Act requires:

- The establishment of a nuclear waste management organization operating on a not-for-profit basis to be responsible for the long-term management of irradiated fuel bundles removed from a commercial or research fission reactor; and
- The creation of trust funds to finance the design, siting, construction, operation and decommissioning of the long-term management facility.

As a result, the Nuclear Waste Management Organization or NWMO was born. The mandate of the NWMO is to "develop and implement, collaboratively with Canadians, a management approach for the long-term care of Canada's used nuclear fuel that is socially acceptable, technically sound, environmentally responsible and economically feasible". This applies to fuel that exists today and to fuel that will be created following refurbishment or new build.

Consistent with this mandate, the NWMO conducted a nation-wide study in 2002-2005 that engaged Canadians in a review of different approaches for managing used fuel over the long term. More than 18,000 people, including 2500 Aboriginal people and 500 specialists, participated in a wide ranging dialogue which, amongst other things, included 120 information and discussion sessions spanning every province and territory. The key messages from Canadians were:

- **Safety and security** is top priority;
- This generation must **take action now;** and
- The approach must be **adaptable** to allow for improvements based on new knowledge or changing societal priorities.

This culminated in the development of a plan for the long-term care of used nuclear fuel called *Adaptive Phased Management* or APM. The Government of Canada approved this approach in June 2007 as Canada's plan for protecting people and the environment over the very long time period in which used nuclear fuel must be managed.

Adaptive Phased Management enables our generation to proceed in a deliberate and collaborative way to establish the foundation for the safe and secure stewardship of used nuclear fuel for the long term in line with best international practice and the expectations of Canadians. The approach requires that used nuclear fuel be contained and isolated in a deep geological repository in a manner that allows for retrieval until a future generation decides on final closure. It includes the creation of a centre of expertise for technical, environmental and community studies that will become a hub for national and international scientific collaboration. The facility will generate thousands of jobs in a host region and hundreds of jobs in a host community for many decades.

The Technology

Figure 1 illustrates the time history for decay of used CANDU fuel. Residual activity is dominated for the first 500 years by the decay of short lived fission products and thereafter by the decay of actinides. Actinides are the group of elements with atomic numbers ranging from 90 to 103 which include uranium, thorium and plutonium. After 100,000 years the residual activity is roughly 10 times that of a naturally occurring uranium ore body and only actinides and long lived fission products such as 129I, 36Cl, 99Tc, and 135Cs remain. After one million years the residual activity reaches a level roughly equal to that in a naturally occurring uranium ore body. It is because of this long time period that a deep geological repository is the preferred method for long-term management of used nuclear fuel.

A deep geological repository is a multiple barrier system designed to safely contain and isolate used nuclear fuel over the long term. It will be constructed at a depth of approximately 500 meters and will consist of a network of placement rooms connected by a series of access tunnels as illustrated in **Figure 2.** Conceptual designs are currently under development within the NWMO for a range of future used fuel volumes using 3.6 million CANDU bundles as the base case and 7.2 million CANDU bundles as an alternate case. The 3.6 million bundle design has an underground footprint of about 2.5 km X 1.5 km and an above ground footprint of about 1 km2 (excluding the rock pile).

About 85,000 used fuel bundles are generated annually and roughly 2 million used bundles have been created to date. Used fuel is stored in wet storage bays at the reactor location where it is produced for 7 to 10 years and then transferred to a licenced dry storage facility on the same site. Thereafter, the bundles are to be loaded into certified packages and transported via road, rail or water to the repository site where they will be repackaged into long-lived corrosion resistant containers and placed underground. Current acceptance requirements specify that the used fuel must have a minimum 30 year out-of-reactor decay period to meet repository thermal design requirements.

The current reference design for the used fuel containers

1 Neale Hunt, Manager – Used Fuel Safety Assessment, NWMO

consists of an inner cylindrical steel vessel that is encased within a thick copper shell (see inset to **Figure 2**). The steel vessel provides mechanical strength sufficient to withstand the local hydrostatic pressure, the swelling pressure due to a surrounding bentonite clay buffer material and a glacial load equivalent to a 3 km thick ice sheet. Glaciation is an important consideration in the design and safety assessment because the geological record shows Canada is covered by glaciers roughly every 120,000 years. The copper shell provides a corrosion barrier for the inner vessel and will be used depending upon site-specific geological conditions. Copper is being considered since it is highly corrosion resistant in the anoxic reducing conditions that exist deep underground. In the current reference design about 10,000 containers are needed to hold 3.6 million CANDU bundles.

The used fuel containers will be placed in either a horizontal or vertical geometry in rooms excavated from the host rock, where the host rock will be either crystalline rock (e.g., Canadian Shield) or sedimentary rock. During the initial development of the Canadian Nuclear Fuel Waste Management Program in the 1980's and 1990's, the focus was on developing a repository in the Canadian Shield. Since then international research has demonstrated that a repository located in sedimentary rock will also provide effective isolation and therefore the APM program has been expanded to include this rock type.

Once placed, the containers will be surrounded by layers of clay-based sealing materials to provide a stable chemical and mechanical environment (see inset to **Figure 2** for vertical geometry). The innermost layer is composed of dense bentonite, a clay that swells as it saturates with water to fill any spaces or gaps, and so provide a tight, low-permeability layer around the container.

A typical placement room for the vertical placement concept would be about 400 m long and contain about 80 containers. The room cross-section and orientation would be selected to maximize mechanical stability under the local host rock stress conditions. As the placement rooms are filled they will be backfilled with clay based materials, sealed from the access tunnel by a concrete plug and monitored for an extended period of time. When a future generation decides to decommission and close the repository, any remaining equipment will be removed and the access tunnels and shafts will be similarly backfilled and sealed.

The project will be implemented in phases and will operate for many decades. It has an estimated cost of $16 to $24 billion; however, the final cost will depend on such factors as the number of fuel bundles, the timing of construction and the site-specific geology. As of January 1, 2010, the estimated present value cost is in the range of $7 to $8 billion. The next generation of baseline cost estimates is expected to be available by 2012.

Site Selection

A repository site has not yet been selected, and the NWMO has neither identified potential host communities nor ruled out certain areas. The NWMO has instead collaboratively developed a site selection process that reflects the ideas, experience and best advice of a broad cross-section of Canadians who participated in a series of dialogues conducted over a two-year period in 2008 and 2009.

The NWMO initiated the site selection process in May 2010. The process consists of a series of steps guided by the following principles:

- Focus on safety and the protection of people and the environment;
- Meet or exceed regulatory requirements;
- Be located in an informed and willing host community;
- Focus on the nuclear provinces;
- Have the right for a community to withdraw at any point until the final agreement is signed;
- Have the siting process and steps triggered by interested communities;
- Ensure respect for aboriginal rights, treaties and land claims;
- Establish shared decision making with the potential host community;
- Be inclusive of the views of others who are most likely to be affected by implementation;
- Assist the potential host community by providing the forms of assistance needed to participate;
- Inform the process by using the best available knowledge;
- Foster community well being; and
- Have the support of all potentially affected provincial governments.

The repository will only be sited in an informed and willing host community and communities which engage in the siting process have the right to end their involvement at any point up until a final agreement is signed. Potentially interested communities can explore their interest in a way they see fit and proceed through each step only if they choose to do so.

As communities express interest, the NWMO will provide information and, if requested, conduct an initial screening and feasibility assessment. Screening factors include the availability of sufficient land located outside protected areas, heritage sites and provincial and national parks; the absence of groundwater resources at repository depth that could be used for drinking, agriculture or industrial uses; the absence of economically exploitable natural resources; and a location that does not have geological and hydrogeological characteristics that would prevent the site from being safe. The NWMO will work with community leaders and other groups to ensure the community is both willing and informed and that the surrounding potentially affected communities are engaged.

While there is no prescribed timetable for implementation as the pace and manner of moving through the site selection process is flexible to ensure the needs of communities are addressed, for financial planning purposes the earliest possible date for repository operation is 2035. Thereafter future generations will decide the nature and extent of monitoring and when to decommission and close the facility. Closure is not anticipated until well into the next century.

Repository Licensing and the Safety Case

The *Class I Nuclear Facilities Regulations* under the *Nuclear Safety and Control Act* classify this type of facility as a Class IB

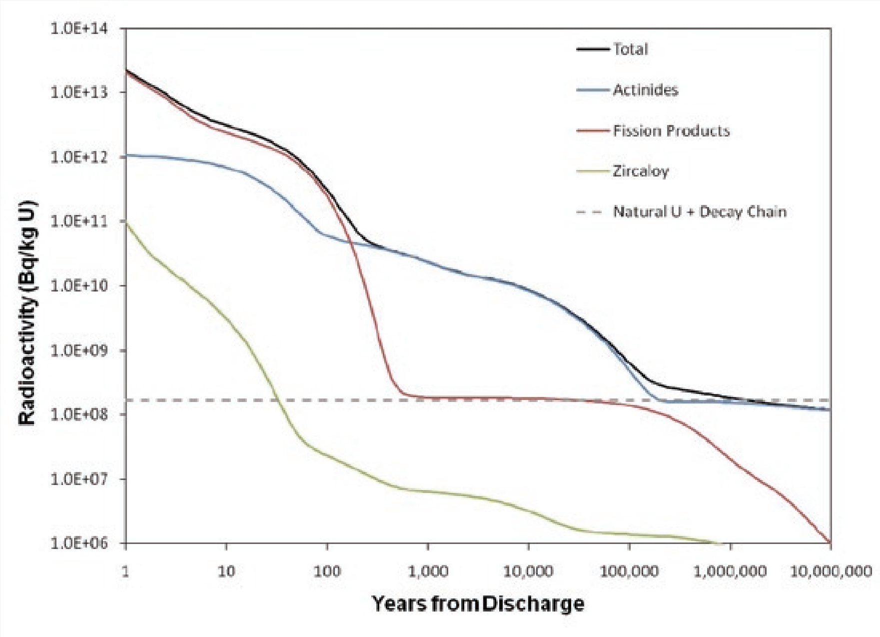


Figure 1: Activity Versus Time for CANDU Fuel with a 220 MWh/kgU Burnup

Nuclear Facility and as such the CNSC is the responsible regulatory authority. CNSC issued licences are therefore required for such repository activities as siting, construction, operation, and decommissioning. Regulatory Guide G-320 *Assessing the Long Term Safety of Radioactive Waste Management* has been issued to provide guidance to prospective licencees.

A licence application is required to be supported by a "safety case". This is an integrated collection of arguments and evidence that demonstrates the safety of the facility. One key element is the demonstration of a good understanding of the site geology and its ability to isolate the repository from the biosphere. Another is the postclosure safety assessment.

The postclosure safety assessment is based on estimates of the dose consequences for a variety of assumed container failure scenarios. To perform such a calculation, computer models are created to represent the used fuel, the container, the repository vault, the engineered barriers, the geosphere and the biosphere. Information is needed for such things as the wasteform, instant release fractions, groundwater composition, wasteform dissolution rate, elemental solubilities, radionuclide sorption coefficients, diffusion coefficients, rock composition, porosities, host rock fault locations, surface topology, lake and river locations, and human and animal characteristics.

Detailed three dimensional modelling of groundwater flow and contaminant transport are performed and conservative assumptions are applied to determine the dose to the critical member of the public. To improve calculation speed, simplifying assumptions are made such that both deterministic and probabilistic (i.e., Monte Carlo) simulations can be performed and a suite of scenarios ranging from likely to "what if" is examined. Cases addressed consider such things as defective containers, inadvertent human intrusion, glaciation, seismic events, the effect of parameter uncertainties and so on. Calculations are generally carried out to span a million year time period to ensure the peak dose is determined.

For the defective container scenario, water is assumed to contact the used fuel very early after placement. Fission products and actinides are thereafter released; however, dose calculations show that almost the entire dose is due to 129I. This occurs since 129I has a high fission product yield, a large instant release fraction, a very long half-life (16 million years) and is not removed by sorption. Actinides, which dominate the used fuel activity after the first 500 years, are released more slowly as the fuel dissolves and are largely sorbed in the geosphere so that essentially none reach the surface (except for uranium and its daughters in the very long term). Calculations for a constant temperate climate case show the peak dose to the critical (or most exposed) individual can be less than 1 μSv/a which is orders of magnitude below both the natural background level of 1.8 mSv/a and the ICRP 81 recommended target dose of 0.3 mSv/a.

While such low dose estimates provide confidence in the safety of the repository system and the selected site, since it is not possible to fully validate the computer codes over the long time periods involved the results are considered as indicators of long-term behaviour only. To provide additional confidence other information is used to supplement the safety assessment. This includes geological evidence at the site and knowledge gained through the examination of natural analogues.

Site geological evidence provides direct information about the ability of the host rock to isolate and contain radionuclides. For example, it can include characterization of porewater in the host rock to show that it is stagnant and old.

A natural analogue is a system in which natural processes similar to those anticipated in a geological repository have occurred over long periods of time. Many natural analogues have been studied to inform the design basis and supplement the safety arguments. A few examples follow.

Cigar Lake is a high grade uranium ore body embedded within a clay deposit 430 m below the surface in Saskatchewan. Despite being over 1.3 billion years old, there is no evidence of its presence on the surface. This provides an argument that supports the stability of uranium oxides and the isolating properties of clay.

Oklo is a series of uranium ore bodies in Gabon which underwent periodic sustained episodes of criticality over a 1 million year period about 2 billion years ago. Studies of this site provide information on fission product and actinide migration in the geosphere.

Dunarobba is a fossil forest in Italy where tree remnants as large as 1.5 m in diameter and 10 m high were discovered still standing upright in a clay deposit. Despite being over 1 million years old, these remnants retain their woody structure and can burn. This provides arguments in favour of the efficacy of clay as a sealing material.

Littleham Cove is a location in England where almost pure natural copper plates were discovered embedded in clay in a reducing environment. Although these have been dated to about

200 million years old, there is almost no evidence of corrosion. This provides arguments in favour of the corrosion resistant properties of copper in a reducing environment and the isolating properties of clay.

Many other natural analogues pertinent to a geological repository have been found around the world and been studied by various organizations.

International Experience

Many countries are considering geological repositories and their programs are in various stages of advancement. Sweden and Finland have selected their repository sites and are currently involved in their licensing process. Japan, Switzerland and the United Kingdom have initiated their siting process and China is conducting preliminary investigations at a location in the Gobi Desert. In the United States a "Blue Ribbon" panel has been tasked with developing a strategy for their program going forward.

The NWMO has contacts with many international organizations and has exchange agreements with national radioactive waste management organizations in Sweden, Finland, Switzerland and France to ensure the best international practices are incorporated in the Adaptive Phased Management approach.

More Information

Additional details on Adaptive Phased Management, the siting process and the long-term management of Canada's used nuclear fuel can be obtained from the NWMO website at www.nwmo.ca.

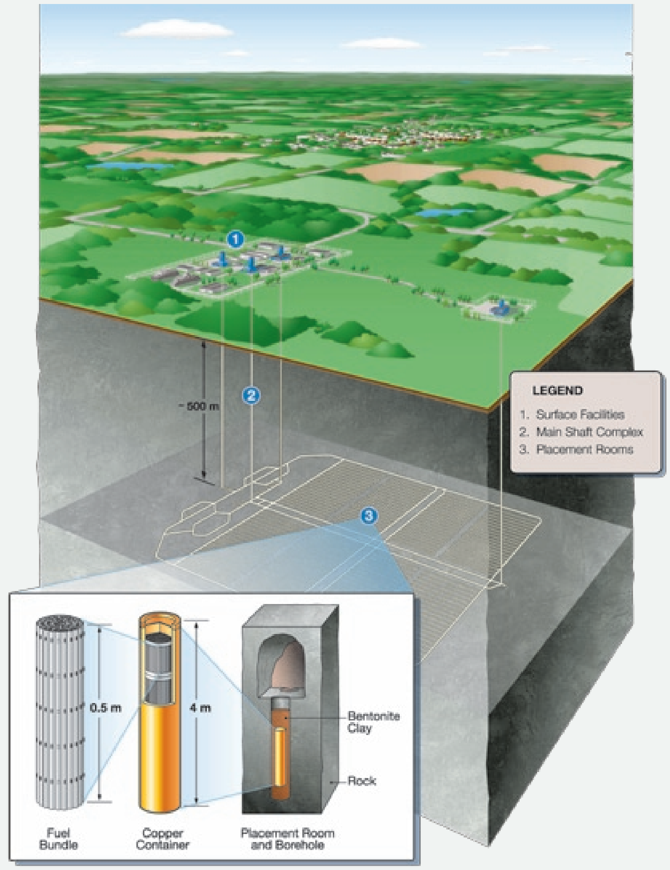


Figure 2: Conceptual Geological Repository With Vertical Placement

Indo-Canadian Nuclear Opportunities

Neil Alexander, President, OCI

On the evening of Sunday 27 June this year, the day the G20 closed in Toronto, the Prime Minister of Canada, the Right Honorable Stephen Harper, held a dinner in honor of His Excellency Dr. Manmohan Singh, Prime Minister of the Republic of India. This dinner, attended by about 700 guests, celebrated the close ties between the two countries and provided an opportunity for the two Prime Ministers to announce the signing of the bilateral Nuclear Cooperation Agreement. This much anticipated announcement drew a standing ovation from the guests, an action that clearly demonstrated the importance of this agreement to the business community and government representatives at the dinner.

India had already signed such agreements with a number of other countries but the Indo Canadian agreement is special because of the shared technological heritage and Canada's expertise in uranium mining and uranium supply. It is likely that the early trading will be focused on fuel issues with this agreement allowing India to continue its economic development without a parallel increase in green house gas production while Canada benefits from the sale of a high added value natural resource. Two way trade will however arise from the shared technology.

The shared heritage started in the 1960s with India's purchase of a Canadian designed Pressurized Heavy Water Reactor (PHWR). Based on the Douglas Point design Rajasthan Atomic Power Plant 1 (RAPP1) was completed in 1973 when RAPP 2, a refinement of this design, was already under construction. Since then PHWRs have gone on to form the backbone of the civilian nuclear industries in both countries with Canada building 32 commercial "CANDU" units leading up to the 900MW Darlington CANDU 9 and the successful export of the standardized CANDU 6 to Romania, Argentina, Korea and China. Meanwhile India completed RAPP 2 on its own and evolved the design to build 16 PHWRs of various sizes to reflect regional needs. One more is approaching completion and the largest units at 640 MW are presently in planning. Although India has so far not exported its civilian nuclear power designs it sees the opportunity in the region as part of the nuclear renaissance and the demand for power in the developing states.

Both countries have research facilities primarily focused on the PHWR concept that have separately been innovating to enhance safety, efficiency, operability, constructability and longevity. Similarly supply chains in both countries have been developing in order to supply the goods and services needed to build, operate and maintain PHWR reactors. Noting that in Canada alone, there are over 165 companies that are part of the Organization of CANDU Industries which supply virtually every aspect of the CANDU Units. There can be no doubt looking at the combination of both countries Supply Chains as well as the best scientists and engineers applying themselves to these Nuclear Plants that some of the innovations will be the same. At the same time some of the developments quite possibly may have gone in different directions. There will be components of different design, different materials will have been utilized and monitoring and control equipment will be different. Even where the design has remained common manufacturing techniques will have changed.

In some cases Canada may have identified the better approach while in others India will have made a breakthrough that Canada may have not considered. The electricity producers in both countries can immediately benefit by adopting optimum solutions for the ongoing operation of their plants while companies that have developed those optimum technologies will double their potential markets. Two way trade will start swiftly for those companies that recognize the opportunity and act upon it. Yes this can be done through simply exporting/importing between the two countries but with conservative buying patterns and the need to satisfy local regulations and regulators the real benefit will likely go to those companies that set up joint working relationships with partners in the other country, optimizing design and production to become the most competitive suppliers to the much expanded market. As well as direct commodity trade the Nuclear Cooperation Agreement will bring about financial transactions and inward and outward investments that will improve commerce for both nations.

Operation of the existing plants is though only a small part of the opportunity. Even greater benefits will be seen in the development of both the Canadian and Indian PHWR new build programs. India is calling for 20,000MWe of nuclear power by 2020 increasing to 63,000MWe by 2032 thereby creating a $25-$50 billion market for new build and opportunities for PHWR suppliers in engineering services, design and construction of plants and subsystems, balance of plant, safety assessments and licensing.

While uranium supply and two way trade in operational support will likely be immediate and the indigenous markets for new build will be large, the real opportunity that the signing of the NCA creates is more competitive Indo Canadian PHWRs that can be sold into third party markets in direct competition to existing light water designs and more rapid progress on innovative PHWR applications that will arise through coordinated research and will lead to reactors that can utilize Thorium and other Natural Uranium Equivalents (NUE) as fuels. These unique capabilities of the PHWR design are not in mass market demand at the moment but are becoming increasingly valuable in niche markets to customers that have limited uranium resources or wish to minimize used fuel volumes. Both India and Canada have already recognized these opportunities and have well developed research programs. Combining these programs will produce more satisfactory results quicker.

The Canadian owner of the CANDU design, Atomic Energy of Canada Ltd (AECL), through its owner the Federal Government is presently seeking partners that will bring the investment, business experience and international presence needed to make CANDU a success in the burgeoning nuclear new build market. It is almost certain that the commercial opportunity created by the bringing together of the CANDU and INDU markets will be high on the agenda for this new partner.

Nothing though is guaranteed. Bringing together markets like this requires vision and it requires effort. At the Canadian end we understand the opportunity and our resources are rallying to commit the effort. Support can be found through nuclear industry associations such as the Organisation of CANDU Industries, international trade organisations such as the Canada India Business Council and both the Canadian Federal Government and the Ontario Provincial Government.

Both Prime Minister Harper and Prime Minister Singh, in making their announcement on June 27, created an opportunity for a highly competitive nuclear business that could see Indo Canadian PHWRS sold in to third party countries while the increased trade in such a strategic area will strengthen the already strong ties between the two countries. The standing ovation was well deserved and I am proud to have been a contributor to it.

[Ed. Note: The above article was prepared for Indo Canadian Business, a magazine published by New Media House in Mumbai.]

Author's note:

As well as saying that bringing together markets like this takes vision and effort I should also have added that it takes appropriate legislative agreement. The article made the assumption that the administrative agreement needed to enable trade would be completed quickly and that legislation in India would be changed to deal appropriately with liability issues. At the time of publication we have no clear date for the administrative agreement and the Indian legislation, while it has been changed, still places long-term liabilities on the suppliers of nuclear goods and services that will be unpalatable to any foreign organisation with a significant balance sheet. It may take longer to realise the vision than I had originally hoped but the opportunity is still out there.

CNSC issues draft regulatory documents

Draft Regulatory Document RD-334, Aging Management for Nuclear Power Plants

The Canadian Nuclear Safety Commission (CNSC) has released for public consultation, draft Regulatory Document RD-334, Aging Management for Nuclear Power Plants. Draft regulatory document RD 334 sets out the requirements of the CNSC for managing aging of structures, systems, and components (SSCs) of a nuclear power plant (NPP). Aging management is the engineering, operational, inspection, and maintenance actions that control, within acceptable limits, the effects of physical aging and obsolescence of SSCs occurring over time or with use. An aging management program (AMP) is a set of policies, processes, procedures, arrangements, and activities for managing the aging of the SSCs for an NPP. Comments are invited before September 27, 2010. For more information about the draft regulatory document, how to participate in the consultation, as well as key links, go to the CNSC website: www.nuclearsafety.gc.ca

Draft Guidance Document GD-369, Licence Application Guide: Licence to Construct a Nuclear Power Plant

The Canadian Nuclear Safety Commission (CNSC) has released for consultation GD-369, Licence Application Guide: Licence to Construct a Nuclear Power Plant. GD-369 describes the structure and content for a nuclear power plant construction licence application.

This document refers to applications for a licence to construct a water-cooled nuclear power plant. This document does not presuppose or limit an applicant's intention to follow any particular kind of water-cooled reactor technology.

In following GD-369, applicants can submit the appropriate information to demonstrate that they are qualified and will make adequate and reasonable provisions to undertake the activity to be licensed, pursuant to subsection 24(4) of the *Nuclear Safety and Control Act* (NSCA) and associated regulations.

The comment period for this draft guide has closed.

Initiation Phase of the Nuclear Refurbishment at Darlington Nuclear Generating Station

M. Freire-Gormaly[1]

[Ed. Note: This paper was presented at the 2010 Annual Conference of the CNS in Montreal.]

Abstract

A nuclear refurbishment project is being performed to extend the operating life of the Darlington Nuclear Generating Station. The Initiation phase is currently being executed, which includes an Integrated Safety Review (ISR), Environmental Assessment (EA) and Integrated Implementation Plan (IIP). This paper outlines the phases involved in a refurbishment project and describes the methodology that OPG has developed to perform the Initiation phase of the Refurbishment project.

1. Introduction

As Canada enters the Nuclear Renaissance, all of the operating nuclear reactors will require refurbishment to continue operation. The government of Ontario suspended the procurement of a new nuclear plant to be built in Darlington on June 29, 2009. The reasons included the economic downturn, higher than anticipated bid prices, and only one compliant bid. The Ontario government has however, committed to maintaining fifty percent of the generation capacity in Ontario from nuclear. To fulfill this commitment a number of refurbishments of nuclear units need to occur.

Ontario Power Generation Inc. has 10 operating units, distributed between the Pickering NGS and the Darlington NGS. All these units are CANDU nuclear reactors, as are all nuclear generating stations in Canada. These reactors are designed to require a mid-life refurbishment outage after about 30 years of service. Refurbishment, also referred to as 'life extension' is a major and complex construction project. It requires significant planning, preparation and analysis to determine the scope of work required. This paper outlines the regulatory requirements, the general methodology and the phases of work involved in a refurbishment, with a focus on the current work being performed by Ontario Power Generation Inc.

2. Refurbishment in Canada

There are a number of recent and on-going refurbishment projects across Eastern Canada. Point Lepreau in New Brunswick is currently under-going refurbishment. Hydro-Quebec has announced a refurbishment of Gentilly-2 in Quebec. Bruce Power is currently performing a refurbishment of Bruce A. Ontario Power Generation Inc. (OPG) conducted an Integrated Safety Review (ISR) of the Pickering-B NGS beginning April 2006, with final submission to the CNSC on September 25, 2009. Most recently, on February 16, 2010, OPG publicly announced its future plans to refurbish the Darlington Nuclear Generating Station (NGS), while the Pickering-B NGS will be operated up until 2020 and then put into safe-storage. A drawing of the Darlington NGS is presented in Figure 1, Darlington Nuclear Generating Station (NGS).

3. Refurbishment at Ontario Power Generation

The Plant Life Extension Project (PLEP) group in Ontario Power Generation was established in February 2006 to undertake feasibility studies for refurbishing and extending the life of the nuclear units at the Pickering and Darlington sites. The organization name was changed to Nuclear Refurbishment (NR) in November 2008. These feasibility studies are required as current medium confidence estimates indicate that the Darlington reactors shall reach their End of Service Life (EOSL) between 2018 and 2020. OPG's Senior Management, with approval by the Board of Directors and Shareholder, tasked NR to assess the feasibility of refurbishing Darlington NGS, plan and then execute the refurbishment to enable operations for an additional 25 to 30 years.

3.1 Regulatory Framework for a Refurbishment Project

The Canadian Nuclear Safety Commission (CNSC) is the Canadian regulatory agency of the nuclear industry. The Nuclear Safety and Control Act (NSCA), which is a piece of federal legislation, provides the objects of the Commission "to regulate the development, production and use of nuclear energy and the production, possession and use of nuclear substances, prescribed equipment and prescribed information." As such, the CNSC has created a suite of regulatory documents (RD). The regulatory document entitled, "RD-360 Life Extension of Nuclear Power Plants"[1] informs licensees, for example, OPG, on a general methodology to consider when performing a project to extend the life of a nuclear power plant. The refurbishment activities described herein were developed to address the scope and intent of RD-360.

Each nuclear power plant in Canada is subjected to ongoing regulatory oversight by the CNSC, in order to ensure that the plants meet modern high level safety goals, and meet applicable regulatory requirements. It is at the return-to-service stage that the licensee must demonstrate that they meet all licence conditions. There are, however, on-going communications with the regulator to ensure a sound process is followed and to ensure overall acceptability of the final documents which outline the processes involved in the refurbishment of the plant.

1 Ontario Power Generation Inc.

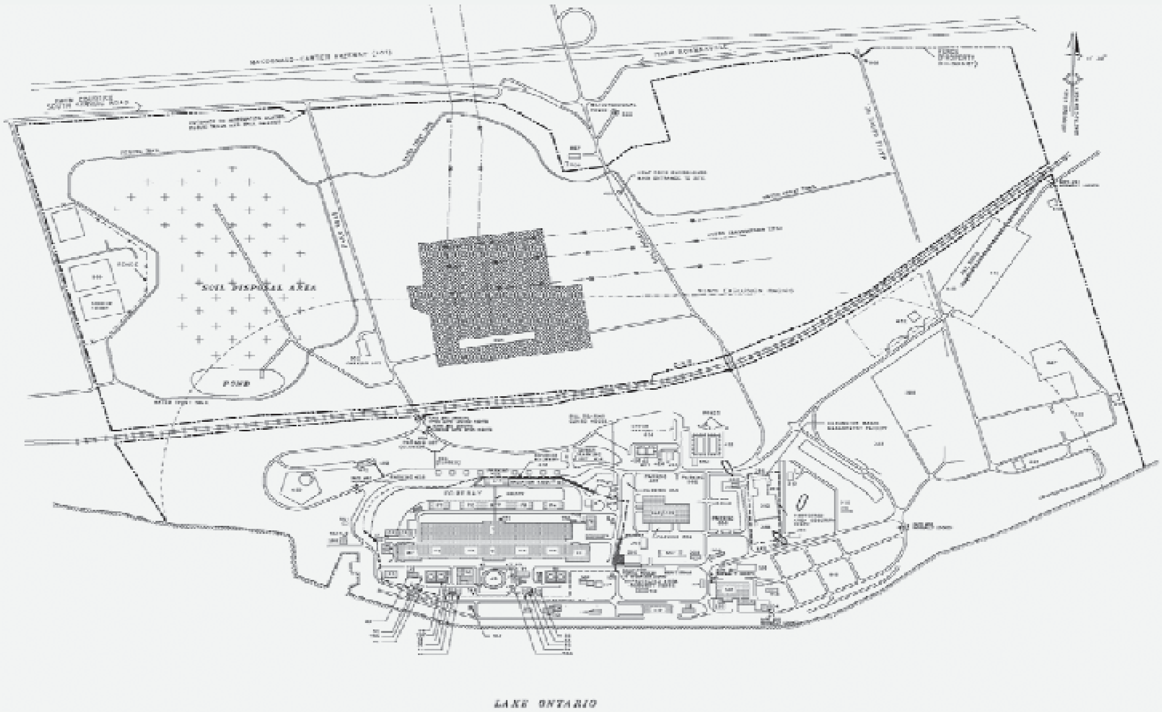


Figure 1. Darlington Nuclear Generating Station (NGS)

3.2 Phases of Refurbishment

OPG developed a phased approach to refurbish the Darlington NGS. The approach is consistent with industry practice and follows an appropriate governance to ensure each phase of the project is performed and documented to meet quality assurance and CNSC requirements documented in RD-360 "Life Extension of Nuclear Power Plants."

The main task prior to performing a refurbishment is to determine the station condition through a full assessment. Depending on the plant condition the refurbishment's scope of work can vary significantly but can potentially include replacement of fuel bundles, replacement of feeders, and the replacement of any life-limiting components, safety and environmental systems.

OPG has defined four phases for the refurbishment, the Initiation Phase, the Definition Phase, the detailed Engineering and Outage Preparation phase, and the Execution Phase. They are defined as follows:

(a) The Initiation Phase is where initial regulatory, outage and scope planning is done and a feasibility assessment on the economics of refurbishing and extending the operational life of the units by an additional 25 to 30 years is completed.

Deliverables in this phase include the following:

- Obtaining, to the extent possible, the necessary corporate, government and regulatory approvals in order that the Darlington reactors can be refurbished in a timely and cost effective manner. The Integrated Safety Review (ISR), Environmental Assessment (EA), Integrated Implementation Plan (IIP) are the regulatory related aspects of the Initiation Phase of the Darlington Refurbishment project.
- Performing technical studies, for example, a plant condition assessment.
- Identifying and approving the project scope and initial outage plans, including cost and schedules, based on results of the regulatory work programs and the technical work programs.
- Ensuring that where necessary long lead items are identified and procurement strategies are in place to support the refurbishment project.
- Incorporating lessons learned from OPG and external sources in determining the material condition of the plant and providing initial planning for the refurbishment of Darlington reactors, including recommendations on refurbishment outage timelines.

(b) The Definition Phase of the project includes preliminary engineering and detailed outage planning in order to finalize project scope, cost and schedule. In this phase, a quality estimate and Business Case Summary (BCS) is developed to support the project recommendations.

(c) The Detailed Engineering and Outage Preparation phase includes detailing the procurement of major component replacement packages and long lead materials, completing detailed engineering and field package assessments, site preparation, and finalizing a detailed project schedule and cost estimate for the outage execution.

(d) The Execution Phase of the refurbishment of the DNGS consists of the refurbishment outage execution and project closeout.

3.3 Initiation Phase

OPG is currently conducting the initiation phase of the project. Three overall studies are performed during this phase, the Integrated Safety Review (ISR), the

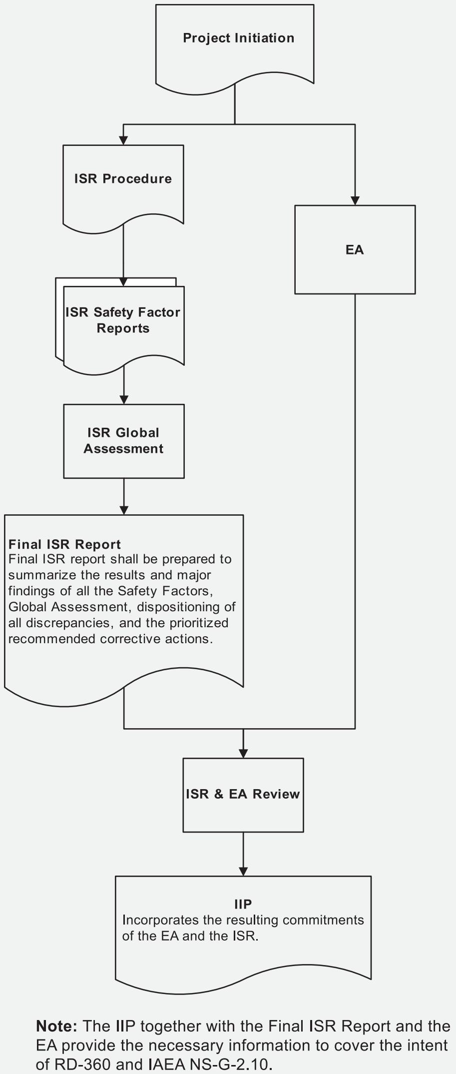


Figure 2. The Initiation Phase of a Life Extension Project

Environmental Assessment (EA) and the Integrated Implementation Plan (IIP). Figure 2, The Initiation Phase of a Life Extension Project outlines the documents that are prepared, and how they are used to cover the intent of RD-360 "Life Extension of Nuclear Power Plants." RD-360 identifies that an Integrated Safety Review should address the Safety Factors from the International Atomic Energy Agency (IAEA) Safety Standards Series, Safety Guide No. NS-G-2.10, Periodic Safety Reviews of Nuclear Power Plants [2], as well as the CNSC safety areas and programs listed in RD-360.

The ISR looks at the existing plant, its history including the programs under which it operates, its physical condition, and its performance whereas the EA is an assessment of the potential environmental impacts of the refurbishment and continued operation of Darlington NGS.

Performing the Initiation phase, as it is closely linked with the regulator, includes a number of activities with the CNSC. Figure 3, Initiation Phase with Integrated Implementation Plan (IIP) and interface with the CNSC outlines the overall process.

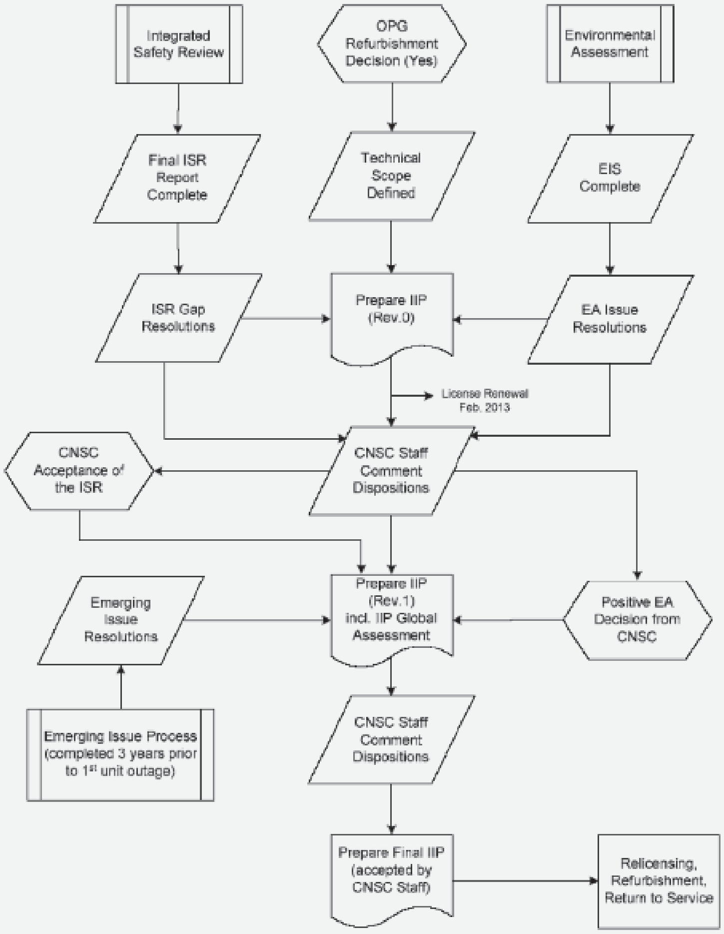


Figure 3. Initiation Phase with Integrated Implementation Plan (IIP) and interface with the CNSC

3.3.1 The Integrated Safety Review

The objectives of an ISR are to determine:

(a) Extent to which the plant conforms to modern high-level safety goals and requirements.

(b) Extent to which the Licencing Basis remains valid, where the Licensing Basis includes the CNSC regulatory framework, documents referenced in the station specific licence, documents submitted by the licensee in support of licence application, and documents referenced therein.

(c) Adequacy and effectiveness of the arrangements that are in place to maintain plant safety for long-term operation.

(d) Safety improvements to address gaps with respect to modern safety requirements identified during the assessment

These objectives are performed to identify any factors that would limit safe long-term operation, and to determine the required mitigating actions to resolve outstanding issues. A schematic of the ISR process is shown in Figure 4, Integrated Safety Review Process.

The Safety Factor Reports that are being prepared for the ISR are based on the Safety Factors included in the IAEA NS-G-2.10 and three additional Safety Factors recommended in RD-360, Security, Safeguards and Quality Management.

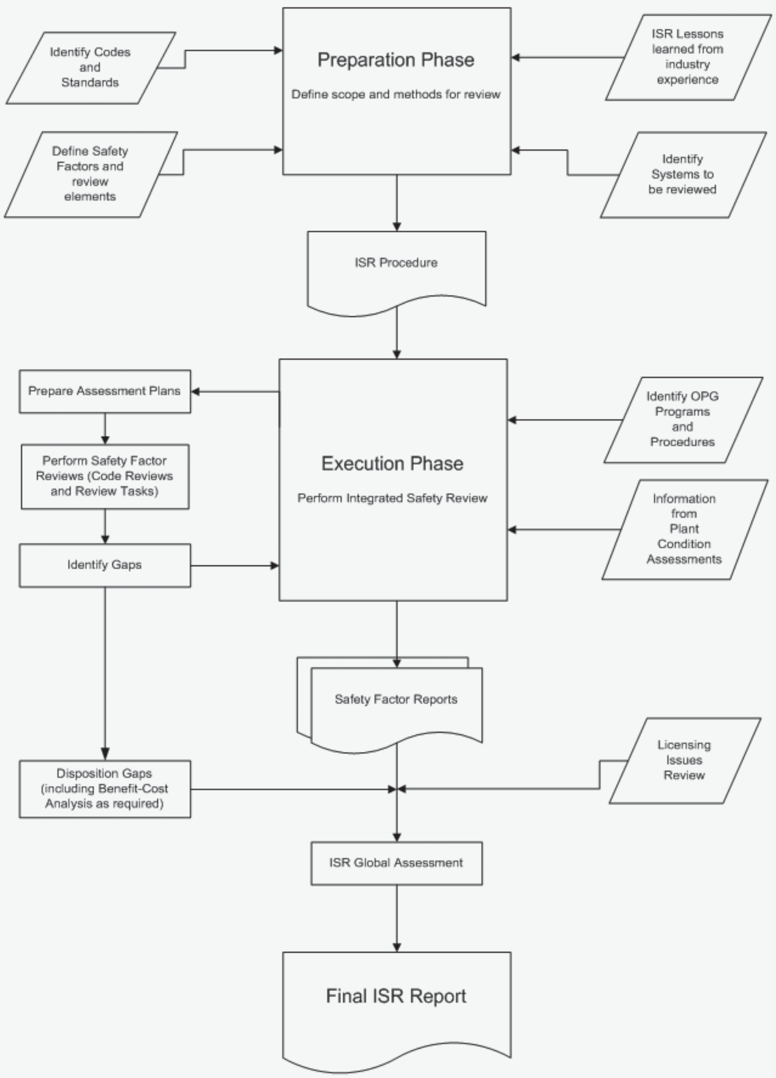


Figure 4. Integrated Safety Review Process

The IAEA Safety Factors are grouped into five subject areas to facilitate the review. A sixth subject area was added to address Security and Safeguards, while the Quality Management Safety Factor was added to the Management subject area. These subject areas and corresponding Safety Factors are listed in Table 1, Safety Factors of the ISR. Each Safety Factor is further broken into Review Tasks which were generated based on the IAEA Review Elements listed in the IAEA NS-G-2.10. Each Review Task is addressed using governance, plant design condition assessments, safety analyses, operation, and related information. The scope of the review considers, as appropriate all expected modes of operation (i.e., normal operation, maintenance, refuelling, shutdown, and start-up activities) to determine whether there is any potential for increased or unacceptable levels of risk. A thorough review of the Darlington NGS safety analyses and OPG governance for operations in conjunction with the operating history of the plant addresses most of the topics that are covered by the ISR.

The ISR also includes a review against modern codes and Standards to assess the level of safety compared to that of modern NPPs. Any gaps that are identified between the current plant state and that required by modern Codes and Standards will be addressed using the Gap Management Process. A summary of the gaps identified in the code reviews will be included in the applicable ISR Safety Factor reports. The Gap Management Process will identify reasonable and practical safety improvements that should be made in order to maintain a high level of safety and to improve the safety to a level approaching a modern nuclear power plant.

The ISR also includes a review of historical and current licencing issues relating to the Darlington NGS as applicable to the various Safety Factors.

Each ISR Safety Factor Report is being produced with the following Table of Contents:

Cover Sheet
1.0 Introduction
2.0 Scope and Methodology of Review
- 2.01 Scope
- 2.02 Methodology

3.0 Findings
- 3.01 Code Reviews
- 3.02 Review Tasks
- 3.03 Issues for Review for Other Safety Factors

4.0 Results and Conclusions
- 4.01 Results
- 4.02 Conclusions

After the completion of the Safety Factor Reports to appropriate quality assurance, an ISR Global Assessment will be performed by a third party. The ISR Global Assessment will assess plant safety for long-term operation and will take into account all unresolved gaps, safety improvements and plant strengths identified in the individual Safety Factor Reports to determine the global risk. The ISR Global Assessment will review the results of the ISR, recommend safety improvements to address individual gaps or groups of gaps, recommend safety improvements resulting from identified opportunities to reduce the overall plant risk, and assess interactions between recommended safety improvements. The results will be prepared and incorporated into the Final ISR report, as seen in Figure 4, Integrated Safety Review Process.

3.3.2 Environmental Assessment

The Environmental Assessment (EA) is being performed in parallel with the ISR. It is carried out under the Canadian Environmental Assessment Act to identify whether refurbishing the Darlington NGS is likely to cause significant environmental effects. The EA is a planning tool to determine the significance of residual environmental effects after applying mitigation measures. It is a process where the environment is characterized, and environmental effects are predicted and assessed before any irrevocable decisions are made about the project.

The Environmental Impact Statement documents the results of the EA. It contains a series of Technical Support Documents (TSDs) which are prepared for different environmental com-

Table 1. Safety Factors of the ISR

Subject Area	Safety Factor
Plant	Plant Design
	Ageing and Actual Condition of Systems, Structures and Components
	Equipment Qualification
Safety Analysis	Deterministic Safety Analysis
	Probabilistic Safety Assessment
	Hazard Analysis
Performance and Feedback of Experience	Safety Performance
	Use of Experience from other plants and of Research Findings
Management	Organization and Administration
	Procedures
	Human Factors
	Emergency Planning
	Quality Management
Environment	Radiological and Non-Radiological Impact on the Environment
Security and Safeguards	Security
	Safeguards

ponents, such as atmospheric, aquatic, surface water, geology and hydrogeology, terrestrial, land use, transportation, socio-economic conditions, aboriginal interests, physical and cultural heritage, radiation and radioactivity, ecological risk assessment and assessment of effects on non-human biota, human health, emergency preparedness, accident and malfunction scenarios, and public consultation. Each TSD includes a detailed description of the baseline field conditions, methodology for the assessment, and assessment of any effects.

Public Consultation is a key element of the EA process. It employs a range of methods to ensure that the public is given notification and has opportunities to participate and may include, but is not limited to the following: notification advertisements, notification letters, stakeholder interviewers and briefings, workshops, community information sessions or open houses, community displays, newsletters, telephone contacts, and a project website.

3.3.3 Integrated Implementation Plan

The Integrated Implementation Plan (IIP) is an integration of the results of the EA and ISR which will identify all necessary safety improvements, proposed plant modifications, safety upgrades, compensatory measures and improvements to operation and management programs that will apply to both the life extension project and to long term operation. It will also indicate the schedule for implementing the safety improvements that need to be completed during the execution phase of the refurbishment project. Similar to the ISR, the IIP has a Global Assessment as part of the final document. Figure 2, Initiation Phase with Integrated Implementation Plan (IIP) and interface with the CNSC outlines the IIP process.

4. Conclusion

A safety review methodology has been developed to demonstrate that the safety and licensing review process for the Darlington refurbishment meets the intent of RD-360 and IAEA NS-G-2.10.

In developing and performing the Integrated Safety Review, the Environmental Assessment and the Integrated Implementation Plan, along with the associated review tasks and methodologies, Ontario Power Generation is confident that it can meet the requirements of the regulator and perform a successful refurbishment of the Darlington NGS through detailed planning and methodical implementation to extend the operating life by 25 to 30 years.

5. References

[1] CNSC RD-360, Life Extension of Nuclear Power Plants, February 2008

[2] IAEA Safety Standards Series, Safety Guide No. NS-G-2.10, Periodic Safety Reviews of Nuclear Power Plants, 2003

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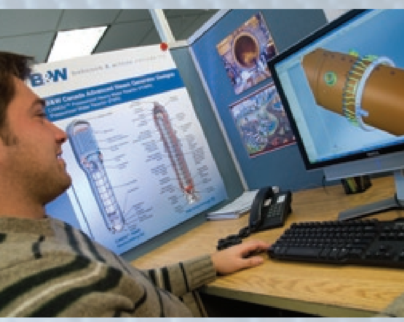



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CNSC Power Reactor Operating Licence Reform

Ken Lafrenière[1]

*[**Ed. Note:** This paper was presented at the 2010 Annual Conference of the CNS in Montreal.]*

Abstract

CNSC staff introduced a new Power Reactor Operating Licence (PROL) in order to strengthen the regulatory oversight of power reactor operation, while increasing regulatory effectiveness and efficiency by focusing on risk-significant issues and reducing purely administrative efforts. The PROLs have been simplified by incorporating a more risk-informed approach and by eliminating cascading references to working level licensee documentation and regulatory expectations.

To ensure that there is a common understanding for each requirement specified in the PROL, CNSC staff prepared a Licence Conditions Handbook (LCH), which provides technical details and compliance verification criteria on how licence conditions are to be met.

1. Introduction

PROLs are typically renewed by the Commission tribunal for a period of five years. However, several challenges in the PROLs have been identified since the coming into force of the Nuclear Safety and Control Act in 2000, such as:

- the lack of clarity in the licence conditions which are not commensurate with the risks;
- inadequate separation between responsibilities of the licensee and CNSC staff; and
- inadequate definition and tracking of the licensing basis.

These challenges have resulted in regulatory efforts on purely administrative matters rather than risk-significant issues associated with the verification of the manner in which the licensee implements their programs.

2. Administration of the Licence

Currently, Class I licences are issued by the Commission and can only be amended by the Commission. The lack of clarity in the licence conditions, including references to licensee documentation in the licence, results in many administrative licence amendments of low safety significance.

As an example, during the 2004-2009 licensing period for a PROL, there were 31 combined amendments processed by CNSC staff in response to over 50 request applications. In addition, CNSC staff and the licensee exchanged significant amounts of correspondence in order to adhere to current requirements in the licence. The total number of correspondence that CNSC staff received from and sent to the licensee exceeded 1400 letters per calendar year.

2.1 Licensing Process

The current practice of administrating the licence has led to CNSC staff being part of the licensee's process rather than, more appropriately, accepting the licensee's process and inspecting for compliance with the licence against regulatory requirements, and taking regulatory actions as appropriate. As a result, the clear separation between responsibilities of the licensee and CNSC staff has become blurred.

The structure and content of previous licences, and the numerous licence amendments, made it difficult for both CNSC staff and the licensee to track the licensing basis over time. To overcome this problem, staff introduced a LCH, which flows directly from each licence condition, to describe and document the intent and compliance verification criteria on how to meet the licence conditions.

2.2 NRU Lessons Learned

In 2007, the extended shutdown of the National Research Universal (NRU) reactor at Atomic Energy of Canada Limited's Chalk River Laboratories led to a review of CNSC practices. In particular, the following findings from the review were considered:

- need to simplify the licence format;
- consistent definition for "licensing basis" for all major facilities;
- process for selection of enforcement tools and ensuring their effective execution;
- process for conducting technical assessments for abnormal conditions or temporary deviations at major facilities; and
- process for action tracking.

2.3 Approach

The basic principles, underlying the revised PROL, can be defined as:

- the licensee is responsible for the safe operation of the plant whereas CNSC staff promotes safety, performs assessments, verifies compliance with the PROL and takes regulatory actions, as appropriate; and
- the PROL clearly defines the requirements of the Licensing Basis at the appropriate level of detail and applies these requirements in a graded manner that is commensurate with the risks.

CNSC staff believes that the implementation of these principles will strengthen the regulatory oversight of NPP operation, while increasing regulatory effectiveness and efficiency by focusing on

1 Canadian Nuclear Safety Commission, Regulatory Program Director

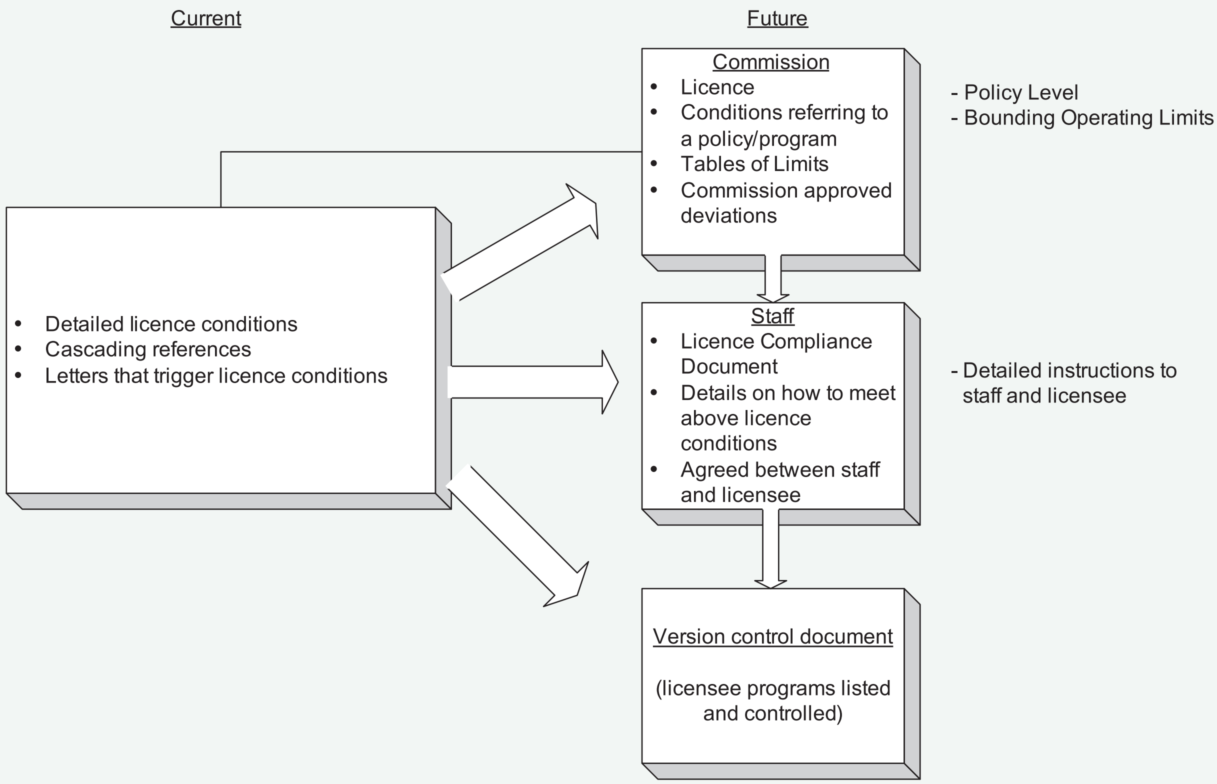


Figure 1: Schematic of PROL changes

risk-significant issues and reducing purely administrative efforts.

As schematically shown in Figure 1, the revised PROLs introduce a clear separation between the licensing and compliance activities. The PROL removes references to individual licensee documents and replaces them with conditions referring to a documented policy or program, specific requirements such as a CSA standard or CNSC regulatory document, and tables of numerical limits such as release limits. A key development is the advent of the new CSA standard N286-05 "Management System Requirements for Nuclear Power Plants. This standard enables an integration of several current PROL conditions by providing quality management principles and specific requirements in several program areas.

In addition, the current suite of available and published standards has enabled staff to propose a regulatory framework that is sufficiently prescriptive. The suite of CSA standards and CNSC regulatory documents in the licence include, among others, the following:

CSA Standards:

- N286-05 "Management System Requirements for Nuclear Power Plants"
- N285.4 "Periodic Inspection of CANDU Nuclear Power Plant Components"
- N285.5 "Periodic Inspection of CANDU Nuclear Power Plant Containment Components"
- N287.7 "In-Service Examination and Testing Requirements for Concrete Containment Structures for CANDU Nuclear Power Plants"
- N290.13 "Environmental Qualification of Equipment for CANDU Nuclear Power Plants"
- N286.7 "Quality Assurance of Analytical, Scientific and Design Computer Programs for Nuclear Power Plants"
- N293 "Fire Protection for CNDU Nuclear Power Plants"
- N285.0 "General Requirements for Pressure-Retaining Systems and Components in CANDU Nuclear Power Plants"
- ANSI/ANS-8 series and N292.3 standards regarding the nuclear criticality safety program.

CNSC Regulatory Documents:

- S-99 "Reporting Requirements for Operating Nuclear Power Plants"
- RD-204 "Certification of Persons Working at Nuclear Power Plants", CNSC document "Requirements for the Requalification Testing of Certified Shift Personnel at Canadian Nuclear Power Plants", CNSC documents EG-1 "Requirements and Guidelines for Written and Oral Certification Examinations for Shift Personnel at Nuclear Power Plants", and EG-2 "Requirements and Guidelines for Simulator-based Certification Examinations for Shift Personnel at Nuclear Power Plants"
- S-210 "Maintenance Programs for Nuclear Power Plants"
- S-98 "Reliability Programs for Nuclear Power Plants"
- S294 "Probabilistic Safety Assessment for Nuclear Power Plants"
- S-296 "Environmental Protection, Policies, Programs and Procedures at Class I Nuclear Facilities and Uranium Mines and Mills"

- S-298 "Nuclear Response Force Standard"
- RD-363 "Nuclear Security Officer Medical, Physical, and Psychological Fitness"

Further to the requirements specified in the PROL, the LCH provides technical details and compliance verification criteria in order to implement the licence conditions. During drafting of the LCH, the content was discussed with the licensee to ensure there is a clear understanding of the intent of each licence condition and that the LCH reflects the commitments of the licensee made in their applications at the time of renewal.

The LCH is administered and controlled by CNSC staff with strict version control and change management. Compliance activities consist of CNSC staff review and acceptance of changes in the licensee's Management System policies; changes in operational programs; and operational changes of low safety significance. CNSC staff review and consent will be required only where explicitly stated in standards. It is important to note that the Commission controls the PROL and the basis on which the PROL was granted. Therefore, approvals of deviations from licence conditions and amendments to licence conditions are subject to the Commission hearing process.

In order to illustrate how changes to the PROL are handled with the revised format, an example is the requirement of the licensee to submit an updated Final Safety Analysis Report (FSAR) every 3 years. In the previous PROLs, the FSAR was referenced directly, and any change (despite the safety significance) required the lengthy process of approval from the commission tribunal (ie. Commission Hearing). However, in the revised PROL, the FSAR is documented in the LCH, and as long as the changes are within the licensing envelope, CNSC staff are able to review, provide consent and reference it as the analysis of record in a much more timely and efficient manner.

3. Path Forward

As approved by the Commission in November 2009, Bruce Power was the first licensee to incorporate the revised PROL and LCH.

The plan is to implement the new licence format at all NPPs during the upcoming renewal cycle as established by the current licence periods of the PROLs. A similar strategy is being developed for all other Class 1 facilities, mines and mills.

4. Conclusions

The revised PROL will ensure appropriate regulatory oversight of power reactor operation and improve clarity, predictability and consistency of the licensing and compliance processes. It introduces a clear separation between review and acceptance of licensee's programs on paper at the time of licence renewal, and in the field compliance verification of the manner in which the licensee implements their programs. The revised PROL allows the licensee to implement continuous improvements following a CNSC accepted systematic and managed improvement process. Furthermore, it clarifies that the licensee remains responsible for the safe operation of the facility whereas CNSC staff will verify compliance with the licence and will take regulatory actions, as appropriate.

Montreal Lecture No. 8

by James E. Arsenault, P.Eng.

1. Introduction

The staff of the Montreal Laboratories of the National Research Council presented 43 lectures in August through October 1945 to the engineering staff of Defence Industries Ltd, to provide the necessary background to enable them to become engaged in the design of the NRX reactor. This reactor was an outcome of the joint war efforts of the United States, United Kingdom and Canada.

The lectures together present a picture of the state of nuclear science at that time and, therefore, are of historic significance in the Canadian context. In particular, Lecture No. 8 is a highly readable account of heavy-water pile theory, by the lead designer of the Zero Energy Experimental Pile (ZEEP) reactor, Dr Lew Kowarski.

Dr Kowarski was born in 1907 in St. Petersburg, Russia. During the Russian Revolution he was moved by his father to Wilno, Poland. In 1928 he received a degree in Chemical Engineering and took an industrial position in Paris. While working he prepared a Doctor's Thesis and eventually began research at the Collège de France. There he joined Dr Pierre Joliot-Curie and Dr Hans von Halban in experiments on neutron emission and became a naturalized citizen of France. When France was invaded in June 1940 he escaped with Halban to the Cavendish Laboratory at Cambridge University and continued the work that showed evidence of neutron emission from fission in a heavy-water uranium oxide slurry. He remained there when Halban, and later their experimental apparatus, left to become director of the newly formed Montreal Laboratories in 1942, which was a joint British-Canadian project. In April 1943, Dr. J.D. Cockcroft took over the Laboratories and Kowarski joined him to become the chief scientist involved with the design of the ZEEP reactor.

A copy of the Montreal Lectures was obtained from the National Archives at Kew, U.K., in early 2008 and permission has been granted to reproduce them in the Bulletin. The 43 lectures were all typed by a stenographer (signed only as J.U.) within a few weeks of each lecture, and comprise about 450 pages.

As for historical context, the lecture, transcribed here, was given on 13 August 1945, a day before Japan surrendered. The formal signing ceremony was on 2 September, and the ZEEP reactor went critical three days later. For more background on The Montreal Lectures and the Montreal Laboratories, see [1] and [2].

2. The Lecture Notes

Lecture No. 8 Montreal, August 13th, 1945

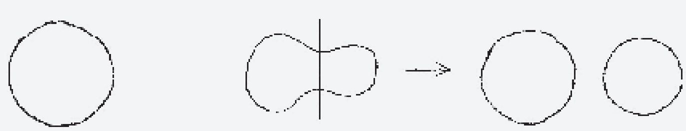
INTRODUCTION TO PILE THEORY

Notes on a lecture given by Dr. Kowarski

A discussion of the elementary characteristics of the physical medium in which the chain reaction takes place - An introduction to Pile Theory.

The nuclei of all atoms are composed of protons and neutrons in almost equal numbers; however neutrons are slightly more numerous and become increasingly so as the atomic weight increases. On following the elements up the periodic table as the nuclei become heavier and more complicated they also become more unstable or "top-heavy". Bismuth (at weight 209) is the heaviest atom which is stable and does not show this "top-heaviness". All atoms heavier than bismuth show signs of natural radio-activity. In 1938, however, it was discovered that uranium exhibited a different kind of instability; this was caused by uranium nucleus entering into a violent state of vibration which caused the nucleus to change from approximately spherical to peanut shape. If this vibration towards the peanut shape is made still more violent by some sort of shock, a disruption or fission occurs, whereby the nucleus is divided into two fragments.

Sketch 1



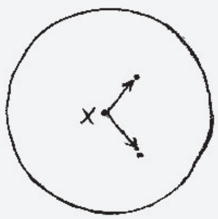
Original or normal Uranium nucleus | Nucleus in state of violent excitation induced by a shock | Two fragments from original nucleus

Considering an individual uranium nucleus it would be necessary to wait an average of approximately 10^{16} years before this fission or rupture occurred spontaneously. However, when a large amount of uranium (say a ton) is studied this spontaneous fission can be readily observed and detected.

This process is very slow, however, and can be hastened or provoked by bombarding the nuclei with X-rays (of high energy), hydrogen and helium nuclei, and neutrons. An apparently spontaneous fission may occur due to neutrons which are present in the atmosphere at all times as a result of cosmic radiations. This effect, however, is extremely weak.

Consider a large lump of metallic uranium in which a single spontaneous fission occurs at point x. As a result of this fission the two fragments fly apart with tremendous velocities releasing energies of the order of 200 M.e.v.

Sketch 2



This represents 30 x 10^{-12} watt. sec. or 30 μμ joules. For one gram of uranium fission energy is equivalent to approximately 22,000 K.W.H.

Immediately after fission occurs the two halves or fragments are in a state of violent excitement and must be stabilized. During the process of stabilization neutrons are given off by each fragment. Considering a very large number of fragments slightly more than one neutron per fragment is emitted on the average. This figure has not been too accurately determined; however, the average number of neutrons emitted per fission (both fragments) is approximately 2.5. These neutrons, after being emitted fly about in the uranium lump and on meeting other uranium nuclei may provoke further fission. This would lead to a chain reaction providing the uranium lump was of sufficient size so that not too many neutrons were lost from the surface and provided neutrons do not lose their effectiveness. In natural uranium, however, this is precisely what happens for the following reasons:

Natural uranium is found to be made up of isotopes in the following proportions:

U^{238} - called 28	139 parts
U^{235} - called 25	1 part
U^{234} - called 24	negligibly small amounts

Immediately after fission the neutrons released have sufficient energies to cause further fission in nuclei of both 25 and 28. However, as the neutrons lose energy through impact and collision with other atoms, they reach energy levels which enable them to be absorbed by the 28 nuclei without giving rise to fission but causing the formation of U^{239}. The 25 nucleus, however, can still be ruptured by a neutron with decreased energy. The 25 nuclei have greater affinity for slow neutrons than the 28 nuclei. The degree of affinity depends on the energy of the neutron. The slower the neutron the more likely it is that it will be captured by 235 with subsequent fission. If the neutrons involved possess the lowest possible energy the number absorbed by the 25 will be just sufficient to keep the chain reaction maintained. Neutrons in this state are called "thermal neutrons" and possess energies of the same order as the surrounding medium.

We shall now define a number which is of great importance in all calculations concerning chain reactions maintained and propagated by thermal neutrons:

$$\eta = \delta f / (\delta f + \delta c)\, \upsilon$$

where η = number of fission neutrons released, on the average, after a thermal neutron has been captured by natural uranium.

δf = "affinity" of the 25 nuclei for capturing neutrons by the process which leads to fission.

δc = "affinity" of natural uranium for neutrons by all other processes

υ = average number of neutrons released by one fission

The value of η then is found to be equal to 1.33. Thus if υ = 2.5 it can be seen that fission will occur in slightly more than one half of all cases.

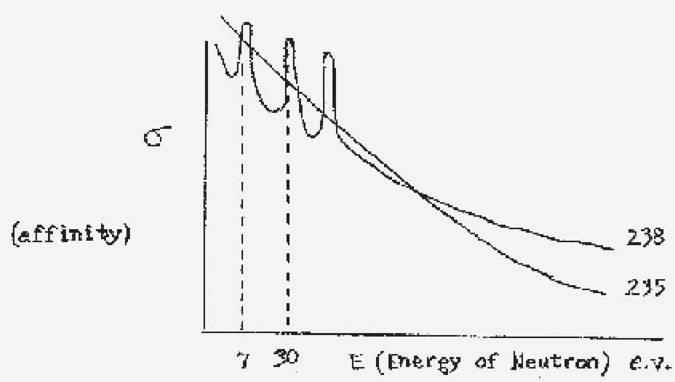
The neutrons released by fission are fast and must somehow be "slowed down", to maintain a chain reaction.

Method of Slowing Down the Fast Neutrons:

This can best be done by the addition of a light element since a neutron loses very little energy by striking heavy nuclei but a great deal of energy by striking light nuclei. If hydrogen is used for this purpose (and the method of mixing a naturally solid element and a naturally gaseous one will not be dealt with here, although this is quite possible if suitable chemical forms are used) the neutron can strike the nuclei of either 25, 28 or H. However, the probability of collision with the H nuclei is overwhelming so that a large percentage of the fast neutrons lose their energy and approach thermal value.

Consider an infinite medium of uranium with 235 and 238 in natural proportions and draw a graph to represent the relative affinities of 235 and 238 for neutrons of various energies.

Sketch 3



The curves represent the affinities of the two isotopes of uranium for neutrons of varying energies. It will be seen that with decreasing neutron energies the affinity of the 235 isotope increases and becomes greater than the affinity of 238 - however, at the approximate energy values of 7 e.v. and 30 e.v. there are two marked high spots on the 238 curve as shown and neutrons in this range are thus "trapped" by the high affinity of 238 in this region. This is called "resonance capture" by 238 and in this range the affinity of the 238 for neutrons is very considerably greater than that of the 235 at the peak points on the curve. (There are other, less important, dangerous spots at energies above 30 e.v.)

Neutrons produced by fission have energies of approximately $2x10^6$ e.v. and when slowed down to thermal regions this energy is approximately 1/40 e.v. In the range 7 e.v - 30 e.v. the neutrons are susceptible to capture by the enhanced affinity of 238. This loss depends on the concentration of the slowing-down material and in the extreme relevant cases may be as high as 30%. Thus η may be decreased from 1.33 to η P1, but the hydrogen also captures neutrons and this expression then becomes $\eta\ P_1\ P_2$,, where P_1 and P_2 represent the fractions which escape capture by the 238 and H. There must also be considered the probability ε of a neutron of high energy causing fission. This increases the 1.33 factor very slightly. The following expression then gives the value "k", the reproduction factor.

$k = \varepsilon\ \eta\ P_1\ P_2$ In order for the chain reaction to proceed "k" must be greater than 1

In homogeneous mixtures of U and H in the proportion U H5 the following approximate values apply to the above equation.

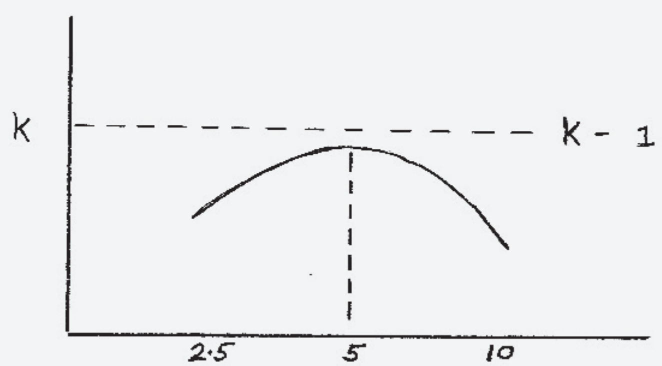
η = 1.33
ε = 1.03
P_1 = 0.75
P_2 = 0.80
k = 0.82

"UH5" = $\frac{1 \text{ of } U}{5 \text{ of } H}$

or $\frac{{}^cU}{{}^cH}$ = 1/5

Thus it is seen that the chain reaction cannot be maintained since k < 1.0. The accompanying graph shows the approximate curve relating "k" to the ratio of concentration of U and H and it will be seen that the optimum value occurs when this ratio is approximately UH5. Hence this is the proportion used. This optimum value occurs when $P_1 = P_2$. The "slowing down" agent used (here hydrogen) is referred to as a "moderator".

Sketch 4 (this is a very schematic view)



C_4/C_5 = proportion of hydrogen to uranium (logarithmic scale)

If carbon is used instead of H for slowing the neutrons its affinity is only about 1/60 that of H for slow neutron

$$\frac{\delta C}{\delta H} = \frac{1}{60}$$

(i.e. the "cross-section" is 60 times smaller than for hydrogen).

However, carbon does not slow down the neutrons as effectively as the lighter elements such as hydrogen, and, therefore, the "skipping" or missing of the danger area of 7 – 30 e.v. is not so complete and the neutron losses to 238 are greater (P_1 decreases). Thus, a homogeneous mixture of U and C is not as effective as a homogeneous mixture of U and H.

Heavy water, D_2O, (polymer) may also be used as a slowing medium and in this case the relative affinities of water and polymer from the neutrons are as follows:

$$\frac{\delta DO1/2}{\delta HO\ 1/2} \sim \frac{1}{300}$$

The oxygen present acts as an almost inert component and has little effect.

The polymer has much less affinity for neutrons than hydrogen but it does not escape the danger range of 238 so well since the deuterium nucleus is heavier than the hydrogen nucleus. However, because of lower neutron affinity, polymer can be used in much higher concentrations. Polymer thus has been found to be quite satisfactory as a "moderator" but at present it is expensive and difficult to prepare.

Instead of a homogeneous mixture of the two media a lattice construction can be used, such as alternate layers of Uranium and the moderator or rods of uranium surrounded by the moderator. The arrangement is much more satisfactory than the homogeneous mixture since the neutrons have a good opportunity of being slowed down past the dangerous energy values while in the moderator layer and thus escaping contact with uranium and capture during that critical moment.

For such a heterogeneous mixture of uranium and carbon the following figures are obtained:

η = 1.33 (probability of fission occurring)
ε = 1.03 (factor favouring fission by fast neutrons)
P_1 = 0.88 (proportion of neutrons escaping resonance capture by 28)
P_2 = 0.88 (proportion of neutrons escaping capture by H)
k = 1.06 (reproduction factor)

Thus since k = 1.06 the chain reaction will be maintained.

If D_2O is used as the moderator for a homogeneous mixture of D_2O and Uranium k ~ 1.05. For a heterogeneous mixture k = 1.24. These figures are for ideal mixtures but in practice there must be considered the removal of heat. The cooling involves the use of aluminum sheathing and water (H2O) both of which capture neutrons and hence decrease "k". At Petawawa Works "k" will be approximately 1.15 in the large pile, 1.20 - 1.22 in the small pile; (since there is no cooling agent in the small pile). For graphite systems used in the U.S.A. k = 1.025 - 1.05

This reproduction factor would be obtained only in an infinite system. What we actually need is a value of k = 1, just to keep the reaction going. Thus the operation can afford to lose a proportion of neutrons equal to the fraction (k-1)/k of the total production. In the case of D2O a relatively small system can maintain this. However, when "k" is as small as 1.025 the fraction available for loss from the surface is small and a very much bigger system is required. We have seen that the simplest possible medium - a homogeneous U & H medium was unsatisfactory, and that a satisfactory improvement could be, and has been, found along the following lines:

(1) Use of a more satisfactory moderating element, which happened to be very rare and expensive (heavy hydrogen).

(2) Use of a heterogeneous lattice arrangement, which reduces losses in the dangerous energy region and allows the use of an inefficient but cheap moderator (graphite).

(3) There is a third way by which the reaction can be obtained even with ordinary hydrogen: The addition of pure 235 will shift the balance by increasing the probability of fission. In the expression given above for η, the numerator is increased, both η and the reproduction factor k go up.

Pure 235, or uranium enriched in 235, can be obtained by isotope separation methods which we cannot consider here. Such separation plants have been built and operated in view of the other aspect of the nuclear chain reaction. It is obvious from the foregoing that in a sufficiently large mass of pure 235 a single spontaneous fission would detonate the entire mass. Hence the only way to handle such pure isotopes would be in relatively small amounts, in which the surface losses of neutrons are large enough to stop the chain.

In such cases it could be possible to cause detonation by bringing two or three quantities together.

The same considerations apply to other pure fissile substances, of which plutonium is an example. Plutonium is an ultimate product of the reaction of 238 with slow neutrons and is formed as a by-product in chain-reaching (*sic*) media considered above, (U + heavy water or U + graphite). Once formed it is relatively easy to extract by chemical means. Thus the two aspects of the chain-reaction industry are interdependent; if we extract, by complicated separation methods, pure 235 from natural uranium in order to use it as an explosive, we can also use some of it for producing a controlled chain-reaction with water. If on the other hand we do not wait for separated 235 and go to the length of producing the controlled chain reaction by using heavy water or very large quantities of very pure U and C, then we obtain, as a by-product, plutonium which can be used as a substitute for pure 235.

/JU
18 Sept./45 Montreal, Aug.13th, 1945

Lecture No. 8 - Introduction to Pile Theory

QUESTIONS AND ANSWERS

1. Do the proportions of U 238 and U 235 remain the same during the course of the chain reaction?

   <u>Answer:</u>

   No. The U235 disappears. In actual operation of the pile the rods are removed long before U235 has completely broken down.

2. How does K vary during the chain reaction and why?

   <u>Answer:</u>

   The overall effect is a slight increase in K. During the reaction there is an accumulation of substances which absorb neutrons due to the formation of new elements. However, at the same time there is a formation of plutonium which is fissile and tends to produce additional neutrons.

/JU
Sept.18/45

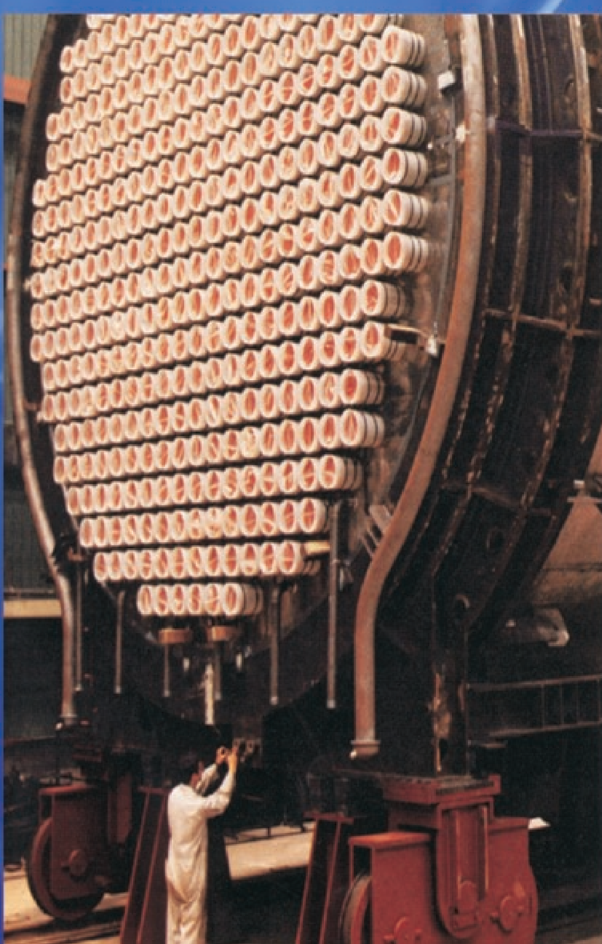
3. Acknowledgments

Thanks are due to Lyn Arsenault who approved the purchase of the Montreal Lectures from the Public Records Office at Kew, U.K., and carefully transcribed Lecture No. 8 from a rather poor copy. Also thanks to Fred Boyd who suggested the idea of republication and provided the usual support and encouragement.

4. References

[1] Arsenault, J.E. "The Montreal Lectures: 2 August–2 October 1944 [sic]". The Canadian Nuclear Society Bulletin, Vol. 28, No. 2, June 2007, 35–41. Note: The lectures were ascertained to have been delivered in 1945 (not 1944) when the copies were obtained from the U.K. National Archives in early 2008.

[2] M.M.R. Williams, Guest Editor. Nuclear Reactor Theory in Canada 1943-1946. Progress in Nuclear Energy, vol.36, no.3, pp237-322. 2000.



GENERAL news

(Compiled by Fred Boyd from open sources)

NRU returned to service

On August 17, 2010, Atomic Energy of Canada Limited announced that NRU was back in service and operating at high power. This marked the successful conclusion of the long and difficult repairs made to the reactor's calandria following the discovery of heavy water leaks in May 2009.

AECL posted a video of President Hugh MacDiarmid and Senior Vice-President Bill Pilkington that day reviewing the long arduous project to return the reactor to service and expressing appreciation to all of the staff and others who managed to overcome all of the challenges of repairing the reactor vessel.

Three days later AECL reported a short shutdown to remove specialized start-up instrumentation and conduct service testing after the return to service.

The ongoing program will be to operate on a 28 day cycle including a five-day outage for planned maintenance and other operations support activities. There will be a longer shutdown in the spring of 2011 to conduct some tests and inspections as required by the Canadian Nuclear Safety Commission.

Some molybdenum 99 was "harvested" on August 18 providing some relief to the medical nuclear imaging community. The return to service also allows research irradiations to begin again and provides the neutron beams used by the team from the National Research Council.

The Canadian Nuclear Safety Commission had held a Hearing on July 5. It subsequently released its decision, as follows:

Based on its consideration of the matter, the Commission concludes that AECL is qualified to return the NRU reactor to service and to carry on the activity authorized by the current licence. The Commission is satisfied that AECL, in carrying on that activity, will make adequate provision for the protection of the environment, the health and safety of persons and the maintenance of national security and measures required to implement international obligations to which Canada has agreed.

Therefore, the Commission approves the return to service of Atomic Energy of Canada Limited's National Research Universal reactor, located in Chalk River, Ontario.

The current licence, NRTEOL-01.07/2011, remains unchanged and is valid until October 31, 2011, unless suspended, amended, revoked or replaced.

With this decision, the Commission directs AECL to provide updates on the progress and effectiveness of the Organizational Corrective Action Plan every six months after the restart of the reactor, to be presented at public proceedings of the Commission. The Commission requires annual in-service inspections of the vessel and the first inspection must be no later than nine months after the NRU reactor restart. The Commission also notes that the vessel leak test was approved by the TSSA and that the acceptance of the final Repair Report by CNSC staff is pending.

Over the period of the repairs and "return to service" program AECL has posed videos of the progress on a special website <NRU.ca> which are still available. They provide an excellent visual record of the examination of the leakage and the development of tools to conduct the very difficult repair the vessel.

Pickering NGS completes decade Vacuum Building inspection

In late May 2010 Pickering Nuclear safely completed its Vacuum Building Outage (VBO) ahead of schedule and on budget. As required by its licence the Vacuum Building attached to all eight units at the Pickering NGS must be inspected and tested every ten years. A major outage is required to allow extensive inspections, testing, and any necessary maintenance of the Vacuum Building equipment and systems. It requires about two years of planning and the shutdown of all six operating reactors. Over 6,000 OPG employees and temporary staff helped complete more than 23,000 tasks during the VBO. Another 7,000 tasks were completed in preparation for the outage.

The Vacuum Building is a safety system unique to CANDU nuclear reactor technology. A large, circular building whose interior pressure is kept close to a vacuum, the Vacuum Building is linked by ducts to all the operating reactors at the Pickering Nuclear generating station. In the extremely unlikely event of a "loss-of-coolant" accident, the steam produced would be drawn into the Vacuum Building where it would be contained and doused with water. This would prevent a rise of pressure in the reactor building and the possible release of uncontrolled radioactive material into the environment.

This was the largest and most complex project that will be completed across Ontario Power Generation's nuclear fleet this year. It builds on the success of last year's VBO at Darlington Nuclear. Following are some of the statistics of the operation.

- Approximately 6,000 employees and contractors participated in the project
- 1,193 tasks completed on April 26 – a one day record

- Just over 30,000 total tasks completed – including 7,000 pre-requisite tasks completed before the outage officially began
- $9.87 million in materials issued
- 557 new valves
- 2,150 lifts to the top of the Vacuum Building using a 200 ft. high elevator
- 10 fully-loaded 45' tractor trailer loads of modular scaffolding used.

TRIUMF to build isotope production accelerator

In late June, 2010 the TRIUMF laboratory in Vancouver announced the construction of a new advanced linear accelerator to produce medical isotopes.

This was made feasible by a $30.7-million investment by the British Columbia government together with a $17.8 million contribution by the federal Canada Foundation for Innovation. TRIUMF and its partners will provide $14.4 million

The linear accelerator named ARIEL (Advanced Rare Isotope Laboratory) will produce intense beams of particles to create isotopes of chemical elements. It uses brand new technology developed in B.C. that produces some of the most powerful beams in the world. In addition to medical applications, the laboratory will expand TRIUMF's capacity for addressing a wide range of issues, including reducing fertilizer runoff, making paper mills more efficient, and developing systems to remove pollutants created by coal-fired plants around the world.

TRIUMF is located on the University of British Columbia's Vancouver campus and is Canada's national laboratory for particle and nuclear physics. It is owned and operated by a consortium of 15 Canadian universities. TRIUMF was started by the University of Victoria, UBC and Simon Fraser University in 1968, when it was called the TRI University Meson Facility.

MDS Nordion produces 2.5 million patient doses of medical isotopes a year at its Vancouver site adjacent to TRIUMF.

Russian nuclear icebreakers clear path for gas shipment

Two Russian nuclear-powered icebreakers will escort a tanker transporting gas condensate from Russia to China via the Arctic rather than through the Suez Canal. The trial run is aimed at slashing the time it takes to ship oil and gas to countries in the Asia-Pacific region.

Sovcomflot's Baltika tanker ship, with deadweight of over 100,000 tonnes, left Russia's north-western port of Murmansk on August 14. It will be joined later by Atomflot's Russia and 50 Years of Victory nuclear-powered icebreakers. The ships will travel some 7000 miles to reach China, compared with the 12,000 miles that it takes to travel via the traditional Suez Canal route. The icebreakers will clear a way through the ice of the Northern Sea Route, which accounts for some 3000 miles of the journey.

Shipments from the European part of Russia to the Far East via the Northern Sea Route have not occurred for many years. However, the latest shipment is the first of its kind using such a high-tonnage tanker via that route. The main purpose of the trial journey, Sovcomflot said, was to determine the possibilities of delivering oil and gas safely and economically to Asia on a regular basis via the Northern Sea Route.

During the voyage, statistical data will be collected to lay the basis for planning similar shipments in 2011 and to further research needed to plot new deep-water shipping routes in the Arctic.

The nuclear-powered icebreaker Russia (Image: Atomflot)

Ground breaking for new Rajasthan units in India

A ground breaking ceremony was held in late August 2010 to mark the start of units 7 and 8 of the Rajasthan Atomic Power Project (RAPP) in India. First concrete is scheduled to be poured at the site before the end of the year.

Excavation work started at the site on August 19, Nuclear Power Corporation of India Ltd (NPCIL) reported. Approval to start the work had been granted the previous day by the Atomic Energy Regulatory Board (AERB).

RAPP 7 and 8 will be 700 MWe indigenously designed pressurized heavy water reactors (PHWRs). The pouring of first concrete for the units is planned for December, after excavation works have been completed. The reactors are scheduled to begin commercial operation in June and December 2016, respectively. The estimated cost of constructing the two units is put at Rs 123.2 billion ($2.6 billion).

In May, Hindustan Construction Company (HCC) was awarded an Rs 8880 million ($188 million) contract by NPCIL to undertake main plant civil works of RAPP 7 and 8. HCC has constructed all six existing units at RAPP, which are also PHWRs of varying sizes, the first of which began operating in 1973 and the latest earlier this year.

The Indian government gave the go-ahead for the construction of RAPP 7 and 8 in October 2009. At the same time, it approved the construction of two further 700 MWe PHWRs at Kakrapar in Gujarat state. The Kakrapar site already hosts two 220 MWe PHWRs, which entered commercial operation in 1993 and 1995, respectively. The larger Kakrapar units 3 and 4 are due to start operating in 2012.

Gentilly 2 refurbishment postponed

On August 16, 2010, Hydro-Québec announced that it had delayed the start of work for the refurbishment of Gentilly-2 nuclear generating station from 2011 until 2012.

As part of its regular maintenance program, the company completed an annual production shutdown of the facility at the beginning of this month and concluded that the equipment is in good working order.

HQ stated that the decision to postpone the start of refurbishing work was taken in light of revised schedules for the refurbishment of CANDU-type generating stations now under way at Point Lepreau (New Brunswick) and in Wolsong (South Korea). Furthermore, the postponement will make it possible to obtain assurances regarding the identity of the future owner of Atomic Energy of Canada Limited (AECL), the main supplier and contractor in the Gentilly-2 refurbishment project.

In February 2009 Hydro-Québec contracted with GE Energy to refurbish the turbine island, including: replacing the two low-pressure steam turbine rotor and diaphragms, the rotor windings and the moisture separator-reheater, and installing a new turbine-generator control system. That work will also be deferred.

Hydro-Québec will continue to invest in regular operations at Gentilly- 2 as it continues to carefully monitor the refurbishment work under way at Point Lepreau and Wolsong, in order to benefit as much as possible from the experience gained.

Gentilly-2, the only nuclear facility in Québec, has an installed capacity of 675 MW and has been producing reliable, safe, non-intermittent and zero-emission power for 25 years. Located near major load centres in the St. Lawrence Valley, Gentilly-2 plays an important role in maintaining the stability and reliability of Hydro-Québec's transmission grid.

L3 MAPPS and B & W Canada supply equipment for Embalse

In early August 2010 L-3 MAPPS, of Montreal, announced that it has received an order from Nucleoeléctrica Argentina S.A. (NA-SA) to supply a full scope operator training simulator for the Embalse nuclear power station. The project will start immediately, and the simulator is expected to go into service at the end of 2012.

The Embalse full scope simulator will use L-3's cutting-edge graphical simulation PC/Windows-based tools for the plant models and instructor station. All of the plant systems will be simulated, including the reactor, nuclear steam supply systems, balance of plant systems, electrical systems and I&C systems. The majority of the simulator's models will be developed, validated and maintained in L-3's Orchid® simulation environment. The plant computer systems, known as Digital Control Computers (DCCs), will be represented with a fully emulated dual DCC that will be integrated in the full scope simulator. The simulator will be equipped with full replica control room panels.

Later in August, Babcock & Wilcox Canada announced it had received a contract to design and fabricate key components and provide manufacturing technology for four replacement steam generators for the Embalse unit. The contract is with the Argentine company Indusrias Metalurgicas Pescarmona Anonima (IMPSA). IMPSA will construct the steam generators and deliver them to Embalse.

The Embalse nuclear power station is one of two operational nuclear power plants in Argentina. It is located on the southern shore of a reservoir on the Rio Tercero, near the city of Embalse in Córdoba Province, 110 kilometers southwest of Córdoba City. The single unit at Embalse is a CANDU pressurized heavy water reactor with a net output of 600 MWe, which went into commercial operation on January 20, 1984. Embalse also produces the cobalt-60 radioisotope, which is used for cancer therapy and industrial applications. With the current plant refurbishment plans, the plant's life is expected to be extended for another 25 years.

AECL appoints new head of Nuclear Laboratories

On August 20, 2010 Atomic Energy of Canada Limited (AECL) announced the appointment of **Dr. Robert Walker** as Senior Vice-President responsible for AECL's Nuclear Laboratories. The appointment is effective November 15, 2010.

Dr. Walker's primary responsibility will be leading AECL's research and development (R&D) efforts in physics, metallurgy, chemistry, biology and engineering. He will also guide the Nuclear Laboratories through AECL's restructuring to maintain the Laboratories as one of the world's foremost nuclear research facilities.

Dr. Walker received his NDC designation from the National Defence College, Ontario and earned a B.Sc. in Physics from Acadia University, Nova Scotia. He also holds an M.Eng. in Engineering Physics and a Ph.D. in Electrical Engineering from McMaster University, Ontario. He is a Fellow of the Canadian Academy of Engineering.

Currently Dr. Walker serves as Assistant Deputy Minister (ADM), Science and Technology of the Department of National Defence, and the Chief Executive Officer of Defence R&D Canada. He has been elected Chairman of the NATO Research and Technology Board (RTB) effective April 2009 and is the principal Canadian representative to the Technology Cooperation Program (TTCP).

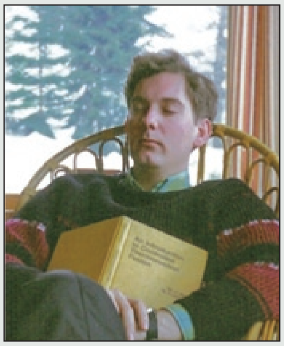
In his current role as CEO of Defence R&D Canada he leads a national network of seven defence research centres with an annual budget of $350 million and a staff of 1600 people in programs addressing a broad range of defence technologies. Defence R&D Canada provides national leadership in defence and security science, and provides scientific advice and products to the Canadian Forces and the Department of National Defence. The defence S&T network extends beyond the Defence Research Centres to encompass partnerships with Canadian industry, universities, and allied defence S&T organizations.


SIMULATIONS AS REAL AS
THE NEED FOR SAFETY

Meet the President

Adriaan Buijs was elected president of the Canadian Nuclear Society for 2010–2011 at the CNS Annual General meeting held in Montreal 25 June 2010. For the past ten years or so we have been running this feature to introduce the current president of the Society. For all of the previous articles the incumbent provided information and we put together what we felt was an appropriate condensed biography. This year, 2010 – 2011 president Adriaan Buijs chose to write his own story. FB.

Adriaan with his wife Soodabeh and sons Arjann and Armin.



Adriaan deep in studies circa 1980.

Adriaan was born in the late '50's while his parents were both students at the University of Amsterdam. Two years later, his father graduated from there with a degree in chemistry, while his mother had interrupted her studies to take care of her son. Adriaan's father decided that Holland was too small and its skies too low, so he took the family to South Africa, where he had received a research position. It is said that Adriaan spoke words of Swahili when he lived there, but he certainly doesn't remember any of them now.

When Adriaan was five years old, the family –meanwhile enriched by another son, Maarten– moved back to Europe, where his father had taken on a position at the nuclear research facilities of EURATOM in Belgium. The facilities were located in Mol, but the family lived in an interesting town called Geel, which was an experiment in psychiatry: the townspeople received a stipend for accommodating mildly mentally disturbed persons in their homes and taking care of them. Adriaan roamed around Geel as a child, surrounded by people who were slightly disoriented. It turns out that this experience comes in handy in Adriaan's dealing with the CNS Council.

Three years later, the family moved again, as Adriaan's father had taken on a position at the EURATOM laboratory in Karlsruhe, which was on the premises of what was then called the Kernforschungszentrum Karlsruhe (KFK), and is now called Forschungszentrum Karlsruhe (FZK). The EURATOM laboratory was called the Institute for Transuranium Elements (ITU), and was established to research the properties of the transuranium elements in the context of the nuclear energy program of the European Community.

Both in Belgium and Germany, Adriaan attended so-called European Schools. These were schools established for the children of the European civil servants working abroad, where he received a good foundation in math according to the French tradition and introductions to Latin and philosophy according to German tradition. The former stuck with him better than the latter.

After high school, Adriaan chose to return to his native land for his university studies. He studied physics in Utrecht, geophysics to be precise, since he wanted to work for Shell like everybody else. For his minor experimental work, however, he joined the nuclear physics group, which was world-famous for nuclear structure measurements on light elements using Van de Graaff generators, ranging in accelerating voltages from 1MV to 12MV (tandem).

Adriaan studied radiative capture resonances (p, γ) in Sulfur-36 using Ge-Li detectors. Although a priceless experimental experience, the subject could not capture (pun intended) Adriaan sufficiently to pursue it for his master's. Instead, he decided to advance the knowledge of nuclear fusion by joining a team of researchers at a small Tokamak at the Plasmaphysics Institute of Nieuwegein, close to Utrecht. There he performed experiments aimed at measuring the temperature of the plasmas in the Tokamak using X-ray detectors. He was offered a PhD position at the institute, but he found Holland too small and its skies too low.

So he left to California to become a graduate student in the group of Prof. Hans Sens at an experiment at the electron-positron collider PEP at the Stanford Linear Accelerator Center, where a group of Dutch physicists were studying interactions between high-energy photons. This work led to his PhD at Utrecht University.

Then, Adriaan joined another, even larger experiment in high-energy physics, again at an electron-positron collider, this time at the European Laboratory for Particle Physics CERN, (where the N once stood for Nucléaire, of course). At CERN he met a young lady who had come from Iran on a 'World Lab' scholarship. These international scholarships were meant for young people from developing countries to get educated and bring their new knowledge back to their home countries. That didn't happen of course, as she would eventually marry Adriaan.

Adriaan had worked at CERN for seven years, when Utrecht University made him an offer he couldn't refuse. He returned to Utrecht to assume a chair in the old nuclear physics group, which by now had moved on to study heavy-ion collisions in international laboratories, among which CERN with its soon to be built Large Hadron Collider. Utrecht's tandem Van de Graaff generator had been converted to perform carbon-14 dating, as was the fate of many such accelerators.

After seven years of being a professor at Utrecht University, he once again found Holland too small and its skies too low, so Adriaan and his family (by now he had two sons), moved to Canada, where Ben Rouben had offered him a position in the physics group of AECL at Sheridan Park in Mississauga, to work on CANDU reactor analysis. Soon Ben introduced Adriaan to the CNS. He became chair of the Sheridan Park branch, and took a turn being secretary. At AECL he moved on to become the manager of the physics design team of the ACR-1000, which was not unlike leading a university team in high-energy physics, but with more QA.

Since 2009 he is a professor at McMaster, in the engineering physics department, where among other things, he is trying to teach students why it is important to measure radiative capture reactions if one wants to understand the behaviour of nuclear reactors.

Student Poster Winners

Part of the 2010 CNS Annual Conference held in Montreal the last week of May was the 34th CNA/CNS Student Conference which was held in the form of a poster competition displayed in the exhibit area. This format proved to be popular and successful.

Delegates were invited to judge the posters and many did.

Through that "democratic" process the following winners were decided:

PhD level: Kevin Daub, University of Western Ontario
Effects of Gamma Radiation Versus Peroxide on Carbon Steel Corrosion

Master's level: Madison Sellers, Royal Military College
An Automated Delayed Neutron Counting System for Mass Determination of Fissile Isotopes in Special Nuclear Materials at the Royal Military College of Canada

Bachelor's level: Sahil Gupta, University of Ontario Institute of Technology
Development of Heat-Transfer Correlation for Water Flowing in Vertical Bare Tubes at Supercritical Conditions

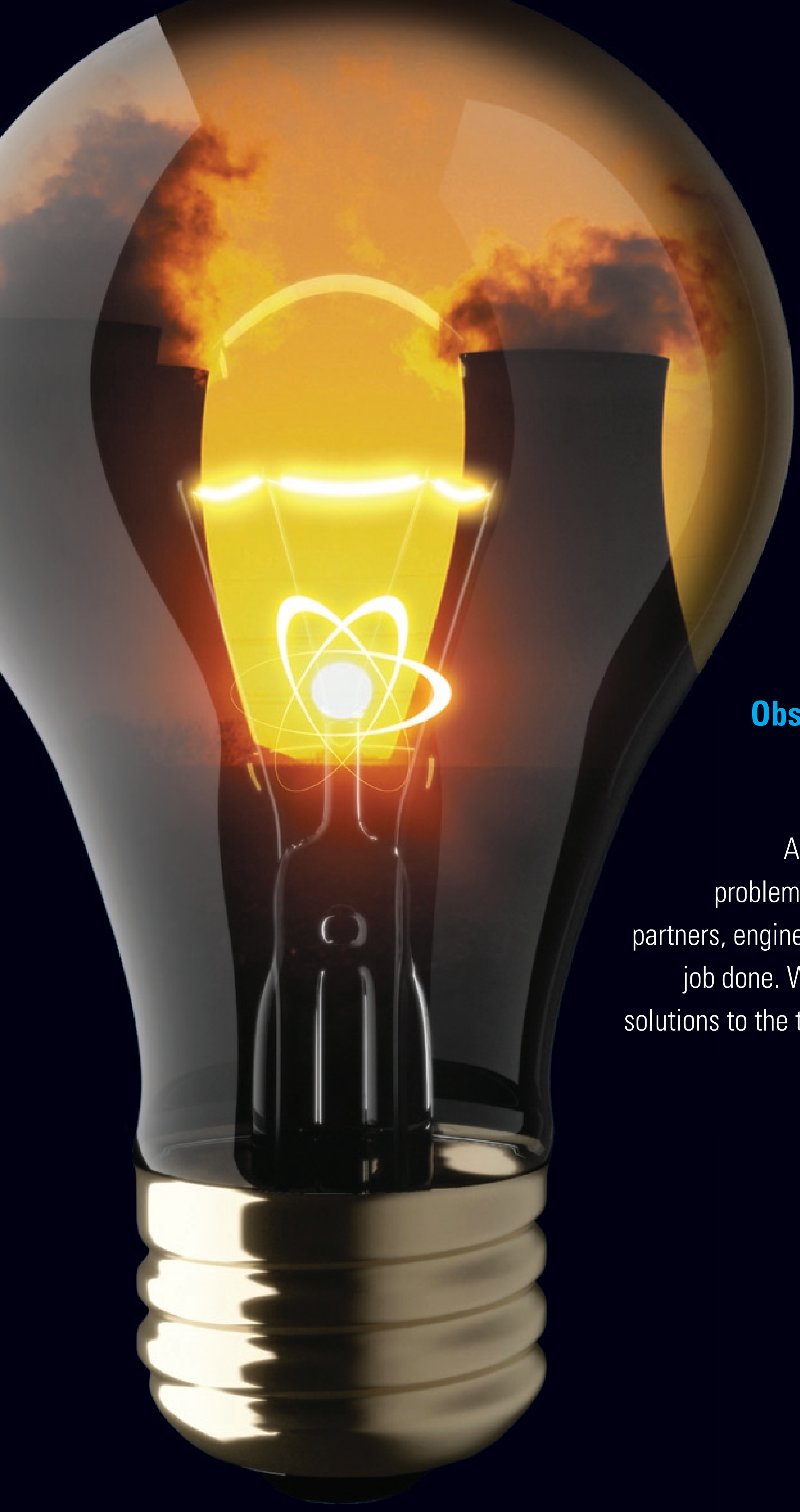
All of the students gathered for a group photo during the poster session.

New Members

We would like to welcome the following new members, who have joined the CNS in the last few months, up to 2010 August 22.

Nous aimerions accueillir chaudement les nouveaux membres suivants, qui ont fait adhésion à la SNC ces derniers mois, jusqu'au 22 août 2010.

Michael Adderley, UOIT
Fayyaz Ahmed, UOIT
Victoria Aldeva
Vinicius Anghel
Saleem Azeez
Reza Azizian
Paul Basi, J.L. Gray
Azin Behdadi, McMaster University
Matthieu Bellanger
Matthew Bond, Trent University
Francois Breton, Dessau Inc.
Ruth Brinston, International Irradiation Association
Canon Bryan, Thorium One International Limited
Henry (Xiao Yu) Cao
Denise Carpenter, Canadian Nuclear Association
Anirudh Chakraborty, UOIT
Madhuri Chatharaju, McMaster University
Michele Cheng-Newson, Lakeside Process Controls Ltd.
Eric Choi, UOIT
Peter Corcoran, CNSC
Dale Cosh, GE
Kevin Daub
Anthony Delija
Claire Dinkel , Nova Machine Products
Daniel Dutil, École De Technologie Supérieure
Pedro Andres Escudero Carbolina, Canada/StonCor Group
Talat Fallahi, AECL
Michel Famery, Dessau Inc.
Sean Forbes, UOIT
Christopher Gallant
Anil Garg, Ontario Power Generation
Anna Kristina Gillin , Candesco Corporation
Rabih Hafez, SNC-Lavalin Nuclear Inc.
Lu Han, SNC-Lavalin Nuclear INC.
Paul Harris
Genevieve Harrisson
Ahad Haseen, ANRIC Enterprises Inc
Maxwell Hayward, UOIT
Helene Hebert, AECL
Derek Hennig, AMEC
René Houle, Dessau Inc.
Susan Howett, University of Western Ontario
Sana Husain, Candesco
Karen Huynh, Natural Resources Canada
Raj Jaitly
Mahsa Jamsaz
Cybele Jewett, AECL
Vipulkumar Kharva
Michael Koivisto, Engineering/Applied Science Trainee
Daniel Kuchar, AECL
Rahim Ladha, AECL
Rahim Lakhani
Ian Leishman, Cameco Fuel Manufacturing
Jane Chun-wai Leung, University of Calgary
Jingli Luo, University of Alberta
Mohammad Malik, McMaster University
Maxim Maltchevski
Michael McDonald, McMaster University
Jeffrey Meade
Pascal Mertins
Bradley Moore, AECL
Njuki Mureithi
Hayden Murray
Maria Cristina Naidin, Ontario Power Generation
Khai Ngo, AMEC
Victory Nkweti Khan
Kathleen Olson, Canadian Nuclear Association
Bob O'Sullivan
Peter Ottensmeyer
Shelly Parker
Andrew Pickeil, UOIT
Igor Pioro, UOIT
Jessica Poupore, Natural Resources Canada
Terry Price, UOIT
Eddie Saab, Lakeside Process Controls Ltd.
Ramesh Sadhankar, AECL
Louis-David Sansoucy, Ian Martin Limited
Jessie Saunders, UOIT
Teguewinde Pierre Sawadogo
Michael Schmidt, Kinectrics Inc.
Anton Sediako, McGill University
Madison Sellers, Royal Military College of Canada
Dheeraj Sharma, UOIT
Sarah Stewart, Univesity of Western Ontario
Kurt Stoll
Liqun Sun, NB Power Nuclear
Bhaskar Sur, AECL
Davinder Valeri, OPG - Nuclear New Build
Anthony John Waker, UOIT
Sheng-Hui Wang, AECL
Shaun Ward
Pamela Yakabuskie
Hussam Zahlan



NEWS FROM BRANCHES

Most CNS Branches tend to be more or less dormant during our short summer. Following are reports from the few that were active.

ALBERTA – Duane Pendergast

1) Back in February, Cosmos Voutsinos completed a report titled "Roadmap for a Comprehensive Energy Policy". It is posted at his website - http://energyintegration.ca. Ralph Thrall of the McIntyre Collegium supported Cosmos in this initiative.

   Subsequently, Cosmos and Ralph met with the MLA for Lethbridge West, Greg Weadick, and secured his help with the distribution of a letter dated July 20 to Alberta MLA's urging that the province undertake long term studies of energy supply and use. It is titled: "OPTIMIZING ENERGY PRODUCTION AND CONSUMPTION: Planning Alberta's Future" and references the report linked above.

2) Cosmos Voutsinos received an invitation from Technology for Emission Reduction and Eco-efficiency (TEREE) and (PTAC) Petroleum Technology Alliance Canada to attend a workshop session for the development of a technology action plan to address challenges and opportunities for energy efficiency, emissions measurement and reduction, best practices and management with due consideration to resource conservation, environmental protection, regulatory compliance and cost management. He will be participating in this, on behalf of the Branch, on September 1st in Calgary.

CHALK RIVER – Ragnar Dworschak & Alex Rauket

DRSA Summer Program

o The branch sponsored and coordinated the DRSA summer talks:
  - Jeremy Whitlock, July 8th, 'Splitting Atoms, Canadian Style'
  - Marylyne Stuart, July 15th, 'Biological Effects of Exposure to Low Levels of Radioactivity'
  - Craig Stuart, July 22nd, ''The Role of Radiation Chemistry in Maintaining Reactor Integrity'
  - Bill Diamond, July 29th, 'My Years as a Physicist at Chalk River Laboratories'

Ongoing Education and Outreach Activities

o The essay competition scholarships have been awarded, and the DRSA graduation ceremony took place last weekend. Ruxandra Dranga attended the ceremony and presented the awards to the two students (Paul Seminsky and Nancy Xiao). See photo in this issue.

o The table below summarizes all the awards, scholarships and programs that we have sponsored this year.

Program / Award / Scholarship 2009 - 2010		Amount
1	Encounters with Canada	$ 600.00
2	Renfrew County Science Fair 2010 (3 students)	$ 900.00
3	Algonquin College Scholarship (Radiation Safety Program) (3 students)	$1,500.00
4	CNS High School Awards for Academic Excellence ($300 * 9 schools)	
	Opeongo H.S. (Renfrew County Enrichment Fund)	$ 300.00
	Madawaska Valley D. H. S. (Enrichment Fund)	$ 300.00
	Mackenzie H.S. (Enrichment Fund)	$ 300.00
	St. Joseph's H.S (Cheque made to school)	$ 300.00
	Bishop Smith Catholic H.S. (Cheque made to school)	$ 300.00
	Fellowes H.S. (Enrichment Fund)	$ 300.00
	Arnprior District H.S. (Cheque made to school)	$ 300.00
	General Penet High School (Enrichment Fund)	$ 300.00
	Renfrew Collegiate Institute (Enrichment Fund)	$ 300.00
5	Deep River Science - CNS Prize for Excellence in Nuclear Research (2 students)	$ 500.00
6	CNS High School Essay Scholarship (competition)	
	1st price	$1,500.00
	2nd price	$1,000.00
	Total	$8,700.00

Academic Awards of Excellence

As part of its education and outreach activities for 2009/2010, the Chalk River Branch of the Canadian Nuclear Society sponsored academic awards of excellence for high school students in Renfrew County. At each of the nine high schools in Renfrew County, the top two students with the highest combined grades in Grade 12 University Preparation physics, chemistry, and math (including calculus), and who were going to be entering a post-secondary institute of education in the fall of 2010 were selected for these monetary awards of $150 each.


From Opeongo High School, in Douglas (Left) are (L to R) Malcolm Cairnie, CNS Member Blair Bromley, and Steven Hawthorne. From Fellowes High School in Pembroke (Right) are (L to R) Wanda Lee, CNS Member Blair Bromley, and Patricia Brum.

GOLDEN HORSESHOE Dave Novog

The GHB branch will be hosting several exciting events in September to coincide with the arrival of students after summer break. The first talk on September 14th will be by Prof. Derek Jackson from the University of Manchester. His topic will cover the work of Osborne Reynolds and includes videos of his original experiments. He will also be providing a lecture on super critical water heat transfer. Also in September we are organizing a joint talk with UNENE by Lorne McConnell (former Senior VP with Ontario Hydro) on the topic of nuclear energy in Ontario. Finally in October, we will be hosting, with CD-ADAPCO, a full day workshop on CFD modelling in nuclear reactor components and coupling to system codes.

OTTAWA – Mike Taylor

The Ottawa Branch will be holding a lunch time meeting on September 7 jointly with the Canadian Nuclear Safety Commission. Ian Grant, a former senior member of the CNSC staff who is now in the UAR, will be speaking on the topic Establishing the nuclear safety infrastructure in the United Arab Emirates.

This will be the second joint meeting with the CNSC, following the very successful one in January on the development and application of the tools to repair NRU.

SHERIDAN PARK – Peter Schwanke

On July 15th, the Sheridan Park branch hosted Dr. Brian Cheadle, whose presentation Development of Zr-2.5 Nb Pressure Tubes for CANDU Reactors was given to a full house. Dr. Cheadle was Head of the Reactor Materials Division before his retirement from CRL. This year he was awarded the Kroll Medal for his contributions to zirconium technology. The award was presented to him at the ASTM biennial conference on "Zirconium in the Nuclear Industry", which was held in China in June. Dr. Cheadle presented the lecture that he gave following his award presentation.

Another afternoon seminar is scheduled for September 8th, and it will host Dr. Peter Ottensmeyer from U of T who will be discussing the application of fast reactors in the energy extraction and the partial detoxification of Canada's used nuclear fuel waste.

A Canadian in the UAE

A little over a year ago Ian Grant resigned his position as a Director General at the Canadian Nuclear Safety Commission to take on the role Director of Nuclear Safety in the newly created Federal Authority for Nuclear Regulation (FANR) in the United Arab Emirates. At that time the UAE was in the final stages of contracting with the Republic of Korea for the construction of four nuclear power plants.

Returning to Ottawa for a three week holiday at the end of August into the beginning of September he contacted his friend and ex-colleague, Mike Taylor, chair of the CNS Ottawa Branch, and offered to talk to the Branch on his experiences in that new position. Mike quickly accepted, and, having had a successful joint meeting with the CNSC earlier in the year, contacted Terry Jamieson of the CNSC. Soon it was agreed to have Ian make his presentation at lunch time at the CNSC on September 7. A large crowd attended.

Ian began his talk by providing some background on the UAE, a small country on the north side of the Arabian Peninsula, which was created in 1971 by the merger of several emirates. It is mostly desert but rich in oil and developing rapidly. Despite its oil reserves the UAE decided to go nuclear for its electricity and chose a bid by a consortium from Korea for four APR 1400 MWe units.

UAE has worked closely with the International Atomic Energy Agency in developing its nuclear program and has a chosen a broad policy of: transparency; non-proliferation; high level of safety; partnerships with corporations and other governments; and sustainability.

As well as setting up the regulatory body it has also created the Emirates Nuclear Energy Corporation to oversee the implementation of the project.

Ian noted that the FANR is still in a building mode and is actively hiring experienced people from around the world. His group currently has 25 members from many different countries. English is the basic working language. They will also be using foreign contracting organizations including one from Canada.

The first regulatory step is a Site Selection Licence, which just allows studies on a potential site. The one being examined is about 250 km east of Abu Dhabi, the capital. Once that has been approved a Site Preparation Licence will be issued. That will be followed by a Limited Construction Licence, currently predicted to be issued in 2012. The plan is to have the first unit start up in 2016.

Among the many comments Ian made during the active discussion session was that the approach to regulation is to have a relatively small number of "high level" regulations which will be augmented with many "guides".

Ian Grant speaks to a join meeting of the CNS Ottawa Branch and the CNSC, 7 September 2010.

Membership Note

It will soon be time to renew your CNS membership for 2011. We hope to have a new CNS-members-only page where you can update your profile if you need to, and where you can renew your membership. We will be sending you an explanatory e-mail when this is ready.

We are very pleased to let you know that the CNS will be maintaining the membership fees unchanged for 2011, even with the advent in Ontario of the Harmonised Sales Tax (HST, 13%), which has replaced the Goods and Services Tax (GST, 5%)!

Note to CNS student members and past student members: As long as you are a CNS member in good standing in the year in which you graduate, you are entitled to a half-price regular CNS membership in the 2 years following your graduation. It is worth it to maintain your CNS student membership in good standing throughout your studies!

Ben Rouben
Chair, Membership Committee

Note d'adhésion

Il sera bientôt temps de renouveler votre adhésion à la SNC pour 2011. Nous espérons avoir bientôt une page internet pour membres de la SNC seulement, où vous pourrez mettre à jour vos données personnelles s'il le faut, et où vous pourrez renouveler votre adhésion. Nous vous enverrons un courriel explicatif quand cette page sera prête.

Il nous fait grand plaisir de vous communiquer que la SNC gardera les frais d'adhésion pour 2011 au même niveau, malgré l'arrivée en Ontario de la Taxe de vente harmonisée (TVH, 13%), qui a remplacé la Taxe sur les produits et services (TPS, 5%) !

Note aux membres étudiants de la SNC : Si vous êtes membre de la SNC quand vous recevez votre diplôme, vous avez droit à un escompte de 50% à l'adhésion comme membre standard pendant 2 ans après avoir été diplômé. Ça vaut la peine de rester membre de la SNC pendant toutes vos études !

Ben Rouben
président du comité d'adhésion

11th International Conference on CANDU Fuel

"Flexible Fuel for a Greener Future"

2010 October 17-20
Sheraton Fallsview Hotel and Conference Centre
Niagara Falls , Ontario
Registration Information (before taxes
http://www.cns-snc.ca/fuel2010.html

Advanced Registration

CNS Member*^	$750
Non-Member*^	$875
Student/Retiree*^	$250
Spouses*	$175

Late Registration—After August 2nd

CNS Member*^	$850
Non-Member*^	$975
Student/Retiree*^	$350
Spouses*	$175

* Includes Registration Reception, 3 breakfasts (Mon, Tue, Wed), banquet dinner and technical tour
^ Includes 3 lunches (Mon, Tue, Wed) and conference attendance

Deadlines

2010 June 15	On-line submission of full papers
2010 June 30	Notification of the acceptance of full papers
2010 July 15	On-line submission of final version of full papers
2010 August 2	End of early-bird registration

"Badge-Draw" Winners at the 2010 Annual Conference

At the end of the Annual Conference, on May 27, 2010, 14 prizes were awarded by random draw from among badges returned by Conference attendees.

The winners:

- Adam Caly, of UOIT, and Stefana Dranga, of the University of Ottawa, each won a CNS sweatshirt
- Gordon Hadaller, of Stern Laboratories, and Terry Jamieson, of the CNSC, each won a book entitled "Canada Entering the Nuclear Age"
- Fred Boyd, CNS Bulletin Publisher, Serge Chapados, of Hydro-Québec, Peter Corcoran, of the CNSC, Yuri Gurevich, of Daystar Technology, Derek Millar, of Ian Martin Limited, Anton Sediako, of McGill University, and Brad Statham, of McMaster University, each won a CNS tie
- Rameshwar Choubey and Richard Jones, AECL retirees, Terry Rogers, Carleton University Retiree, each won a complimentary CNS membership good to end of 2011.

Congratulations to all the winners!

Gagnants de prix au tirage des porte-insigne de la conférence annuelle 2010 de la SNC

À la fin de la conférence, le 27 mai 2010, 14 prix ont été tirés au sort parmi les porte-insigne retournés par les participants à la conférence.

Voici les gagnants des prix:

- Adam Caly, d'UOIT, et Stefana Dranga, de l'Université d'Ottawa, ont chaqun gagné un chandail sport de la SNC
- Gordon Hadaller, de Stern Laboratories, et Terry Jamieson, de la CCSN, ont chaqun gagné une copie du livre « Canada Enters the Nuclear Age »
- Fred Boyd, Éditeur du Bulletin de la SNC, Serge Chapados, d'Hydro-Québec, Peter Corcoran, de la CCSN, Yuri Gurevich, de Daystar Technology, Derek Millar, d'Ian Martin Limited, Anton Sediako, de l'Université McGill, et Brad Statham, de l'Université McMaster, ont chaqun gagné une cravate de SNC
- Rameshwar Choubey et Richard Jones, retraités de l'EACL, et Terry Rogers, retraité de l'Université Carleton, ont chaqun gagné une adhésion gratuite à la SNC, valable jusqu'à la fin de 2011.

Félicitations à tous les gagnants!

2010-2011 CNS Council • Conseil de la SNC

Front row, left to right (seated): Peter Lang, Nick Sion, Syed Zaidi, Prabhu Kundurpi, Ben Rouben, Kris Mohan. "Middle" row (standing): Jad Popovic, Tasfia Preeti, John Roberts, Dorin Nichita, Frank Doyle. Back row (standing): Claudia Lemieux, Parvaiz Akhtar, Mohinder Grover, Mohamed Younis, Melanie Sachar, David Novog, Ken Smith, Adriaan Buijs

Missing: Blair Bromley, Emily Corcoran, Krish Krishnan, James Lévêque, David Malcolm, Jacques Plourde, Len Simpson, Michael Stephens, Jeremy Whitlock, and Fred Boyd (who took the photograph).

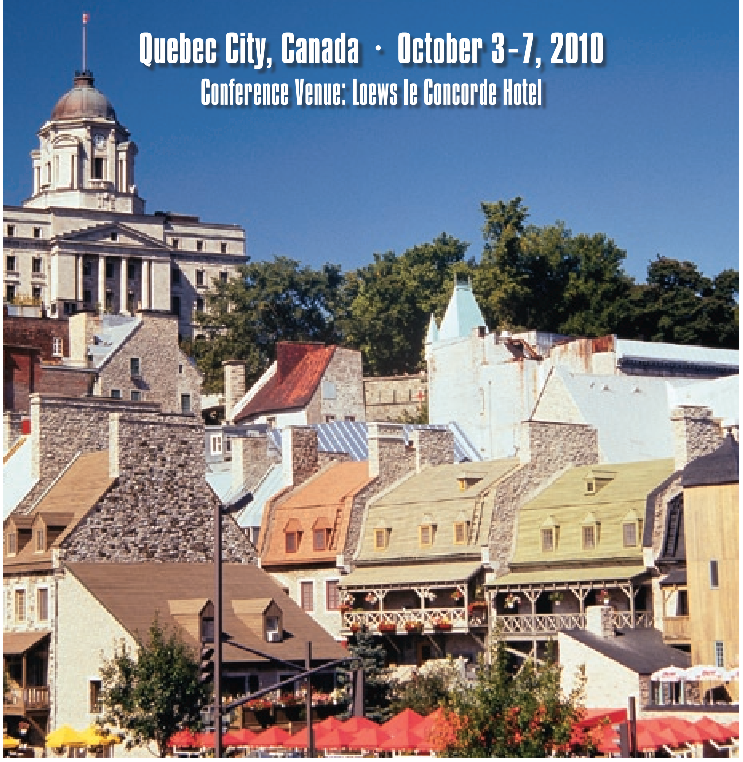
NPC 2010

Nuclear Plant Chemistry Conference 2010

(International Conference on Water Chemistry of Nuclear Reactor Systems)

Quebec City, Canada · October 3-7, 2010

Conference Venue: Loews le Concorde Hotel



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

Features of the Conference

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

Loews le Concorde Hotel – located within minutes walk from the heart of old Quebec City, is the perfectly located and appointed venue. Contact the hotel as soon as possible for reservations.

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

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

Radiolysis, Electrochemistry & Materials Performance Workshop

The 8th International Radiolysis, Electrochemistry & Materials Performance Workshop will be held as an associated, but otherwise free-standing, event on Friday, October 8, 2010. Papers selected from requests for invitation to speak will be presented. For organization and registration information regarding this Workshop, see the website at **www.cns-snc.ca**

NPC2010 Program

Technical papers will be presented in the following topic areas. There is special interest in the experience of plants with Alloy 800 as well as of those with Alloy 600 and Alloy 690 steam generator tubing.

- Chemistry and NPP Performance
- PWR, VVER Operating Experience
- CANDU/PHWR Operating Experience
- Pressurised Water Scientific Studies
- Steam Cycle Operating Experience
- BWR Operating Experience
- Boiling Water Scientific Studies
- Water and Waste Treatment, Cooling Water Systems, Auxiliary Systems
- Materials Aging and Mitigation of Degradation
- Chemistry and Fuel Performance
- Cleaning and Decontamination
- Lifetime Management
- Chemistry Optimization Programs
- Chemistry Compliance Management
- Future Developments (GEN IV), Supercritical Water

A total of 54 oral presentations will be made over the four days of the Technical Program and the Poster Program is proving to be a large and dynamic part of the Conference with 120 posters to be displayed and presented through multiple Poster Sessions.

*** Sponsorship Opportunities ***

A number of opportunities remain for Sponsorship of various Conference Activities. Sponsorships providing assistance to Students for Participation in this important event are also available. Sponsorships include Sponsor recognition within the Final Program and at the Conference itself – don't miss this chance for recognition as an active supporter of the work and objectives of NPC 2010. To inquire, contact: Elizabeth@theprofessionaledge.com or call 1-800-866-8776.

Conference Information

For additional information on the Conference go to **www.cns-snc.ca**.

Registration

To register for the Conference and Workshop go to **www.cns-snc.ca**.

Event Administrator – The Professional Edge

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

Conference Sponsor and Organizer

The Canadian Nuclear Society is pleased to serve as the sponsor and organizer of the NPC 2010 Conference.

IAEA – This Conference is held in cooperation with the International Atomic Energy Agency; in certain circumstances the IAEA will provide assistance for attendance. Please contact John Killeen at the IAEA for details (J.Killeen@iaea.org).

Nuclear @ NIAGARA

CNS 2011 SNC

Niagara Falls June 5-8, 2011

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

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

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

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

Important Dates:

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

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

Paper Submission

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

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

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

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

Current Practices and Future Needs

The Canadian Nuclear Society is pleased to announce a conference on **Waste Management, Decommissioning and Environmental Restoration for Canada's Nuclear Activities,** to be held September 11-14, 2011 at the Marriott Toronto Downtown Eaton Centre, in downtown Toronto. An equipment and services exhibition is planned in conjunction with the conference.

Second Announcement and Call for Paper Summaries

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

The conference is organized into plenary sessions and concurrent technical tracks and papers are being solicited for the Technical Sessions.

Topics to be addressed during the conference will include the following:

- Near-surface disposal of very low level waste
- Low and intermediate level waste management issues, with an emphasis on geological disposal and operational issues faced by waste-producers such as waste segregation, characterization, verification; treatment and processing; waste minimization, and waste inventories
- Uranium mining, milling and conversion wastes
- Transportation
- Used nuclear fuel, with an emphasis on geological disposal, but including storage practices
- Decommissioning and environmental remediation, including that of old waste management facilities
- Licensing and regulatory considerations, including standards and clearance criteria
- Social issues, including siting of facilities, and decision-making criteria and processes

Deadlines

- Submission of Paper Summaries: October 4, 2010
- Author notification of acceptance: November 12, 2010
- Submission of full papers: May 13, 2011
- Comments to authors on papers: August 15, 2011
- Submission of final full papers: September 11, 2011

Guidelines for Submission of Paper Summaries

Paper Summaries should be approximately 750 to 1200 words in length (tables and figures counted as 150 words each).

They should include:

- an introductory statement indicating the purpose of the work
- a description of the work performed
- the results achieved

Summaries are to be submitted no later than October 4, 2010 by e-mail to Mark Chapman: **CNSP2011@aecl.ca**

For more details see the conference website http://www.cns-snc.ca/events/waste-management-decommissioning-and-environmental/

Post Conference Technical Tours

Technical tours are being planned to three Canadian nuclear facilities: the Low-Level Radioactive Waste Management Office activities at Port Hope, the Darlington Used Fuel Dry Storage Facility, and the OPG Western Waste Management Facility at the Bruce site.

Questions regarding papers and the Technical Program should be addressed to:

Mark Chapman
E-mail: CNSP2011@aecl.ca

General questions regarding the Conference should be addressed to:

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

Questions about Conference registration should be addressed to:

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

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Ken Dormuth (AECL retired), *Plenary Session Chair*
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Don Howard (Canadian Nuclear Safety Commission)
Kathleen Hollington (Natural Resources Canada)
Janice Hudson (OPG)
Dave McCauley (Natural Resources Canada)
Jamie Robinson (NWMO)

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

CALENDAR

2010

Oct. 3-7
International Conference on Water Chemistry of Nuclear Reactor Systems (NPC 2010)
(organized by CNS)
Quebec City, QC
website: www.cns-snc.ca

Oct. 10-14
8th International Topical Meeting on Nuclear Reactor Thermalhydraulics, Operation & Safety (NUTHOS-8)
Shanghai, China
website: www.nuthos-8.org

Oct. 17-20
11th International Conference on CANDU Fuel
Niagara Falls, ON
website: www.cns-snc.ca/fuel2010.html

Oct. 24-28
9th International Conference on Tritium Science & Technology
Nara, Japan
email: uda.tatsuhiko@nifa.ac.jp

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

Nov. 1-3
Technical Meeting on Low-Power Critical Facilities and Small Reactors
Ottawa, ON
website: www.cns-snc.ca/events/tmlpcfsr

Nov. 7-10
AMP2010 International Workship on Aging Management of Nuclear Power Plants and Water Disposal Structures
Toronto, ON
website: www.amp2010toronto.com

Nov. 7-11
2010 ANS Winter Meeting and Nuclear Technology Expo
Las Vegas, Nevada
website: www.ans.org/meetings/m_74

Nov. 7-11
Embedded Topical: Isotopes for Medicine and Industry
Las Vegas, Nevada
website: bmd.ans.org/isotopes.shtml

2011

March 13-16
5th International Symposium on Supercritical-Water-Cooled Reactors (ISSCWR-5)
Vancouver, British Columbia
Call for papers
website: www.cns-snc.ca/events/isscwr-5/

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

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

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

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

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

Oct. 2-5
Canadian Nuclear Society Conference on the Future of Heavy-Water Reactors
Ottawa, ON
website: www.cns-snc.ca/events/cns-fhwr/

Call for Papers

"Technical Meeting on Low-Power Critical Facilities and Small Reactors"

Ottawa Marriott Hotel
Ottawa, Ontario CANADA
2010 November 1-3

"Celebrating ZED-2's 50th Anniversary"

Objective

The Zero Energy Deuterium (ZED-2) Critical Facility, located at AECL's Chalk River Laboratories will be celebrating its 50th Anniversary this year. Built in the late 1950s, ZED-2 achieved first criticality on September 7, 1960. ZED-2 was initially built to test the fuel arrangement of Canada's first nuclear power plant, the Nuclear Power Demonstration (NPD), located along the shores of the Ottawa River about 20 km upstream of Chalk River. ZED-2 was the successor to the first nuclear reactor outside of the United States, the Zero Energy Experimental Pile (ZEEP), which was designed to investigate lattice physics and reactor kinetics. Since that time, the ZED-2 critical facility supports the development of the CANDU industry by testing a wide range of fuel bundle designs, fuel arrangements at low power under a variety of operating conditions and simulating accident scenarios. ZED-2 continues to operate today, supporting the current CANDU fleet, development of the Advanced CANDU Reactor and advanced fuel cycles including thorium fuels.

To mark the historic occasion of ZED-2's 50th anniversary, a Technical Meeting to showcase the numerous accomplishments of low-power critical facilities worldwide will be held in Ottawa in early November. The two-day Technical Meeting will cover topics of interest to operators, experimenters and analysts involved with low-power critical facilities. Following the conference, AECL will host all interested attendees for a day at the Chalk River Laboratories, with the highlight being a tour of the ZED-2 critical facility.

Key Deadlines

Abstract submission Sept.17, 2010
Notification of acceptance.........................Oct. 8, 2010
Early registration deadline ....Sept. 15, 2010

Abstract Submission

Abstracts must be submitted via an on-line submission link, which will be posted on the CNS webpage at http://www.cns-snc.ca. Abstracts/ extended abstracts, up to three pages in length, and participants' presentations will be published on CD in the Conference Proceedings.

Conference Organizers

Honorary Co-chairs..............................Ralph Green, Chas Millar
Rick Jones, John Hilborn
General Chair..Bhaskar Sur
Technical Program Co-chairs ....Alex Rauket, Milan Ducic
Program Committee..Peter Boczar
Ken Kozier
Rick Didsbury
Dave Irish
Bruce Wilkin
Brock Sanderson
Julian Atfield
Mike Zeller
Elisabeth Varin

Topics of Interest

Papers related to the following topics are of interest to this conference:

- Safety and licensing of critical facilities
- Measurements in critical facilities
- Analysis of measurements from critical facilities
- The use of measurements from critical facilities in reactor physics code validation
- Extension of bias and uncertainty from the critical facility to the test reactor
- Other uses of measurements from critical facilities
- Design development of instrumentation for measurements in or control of critical facilities
- Different fuel compositions, geometries, reactivity worth of devices, kinetics parameters, reactor types
- Measurements of irradiated materials, actinides
- Reactor physics benchmark databases and activities
- Education and research with small reactors

Further Information

Additional information may be obtained by contacting Technical Program Co-chair: Milan Ducic, AECL, Chalk River Laboratories, Chalk River, Ontario K0J 1J0 CANADA, Tel: (613) 584-3311;
Email: ducicm@aecl.ca

On the Other Hand

by Jeremy Whitlock

Folks in the nuclear industry are generally of the "glass-half-full" sort. Or rather, folks STILL in the nuclear industry are generally of this sort, because you don't stick around long if you're not.

The "half-full/half-empty" thing has been around since the industry's inception. The basic science, after all, is the science of doomsday weapons. On the other hand it's also the science of the most sustainable energy source on the planet. Both the yin and the yang were as true in the 1940s as they are today.

We're a public relations nightmare because of this. Surviving in this game basically means managing bad news on an almost daily basis: never mind what you hear on the morning news on the way to work; it's the version circulating by first coffee break that comes closer to the truth.

Radiation causes cancer. On the other hand, radiation cures cancer. The self-contradiction is, quite literally, in our blood.

We used to be much better at it. We once partially melted a research reactor core at Chalk River, which, in 1952, was the first major reactor accident on the planet. On the other hand, with nobody hurt and all radioactivity contained, it immediately presented itself as an unprecedented opportunity: an opportunity to teach the world about new reactor safety concepts, an opportunity to develop large-scale decontamination and environmental mitigation processes, and an opportunity to rebuild a reactor (then five years old - the end of its initially predicted lifespan) and upgrade its performance.

In 14 months the NRX was operating again, with a new core and new control systems: safer, more powerful, and ready to serve for decades to come. It suffices to say that the government of the day was the "glass-half-full" type.

We've had more than our share of kicks in the pants since: uranium fuel on fire, pressure tubes failing prematurely, lead blankets and plywood covers left inside cooling systems, pump impellers rattling fuel to pieces, turbines dropping into the Bay of Fundy, reactors going over budget, reactors being cancelled, reactors going supercritical and then almost being cancelled, seven of Ontario's CANDUs laid up simultaneously, refurbishments behind schedule, pumps without backup to their backup power, and regulator Presidents getting sacked.

These were all "bad days". Most taught lessons. Some changed the industry. All were survived.

Which brings us to 2010.

In the "annus horribilis" of 2010, a perfect storm of bad news buffeted the nuclear community from all sides:

The NRU reactor, fresh from the media circus of 2007 that ultimately decapitated the CNSC, limped into its 15th month of repairs in August, with every excruciating detail of its inspection, welding, re-welding, and schedule slippage paraded before the salivating media along the way.

Refurbishment projects across the country, in many ways as complicated, or more, than new build projects, fell further behind schedule.

Ontario continued to stick its head in the sand on new reactor construction, while throwing money at solar and wind projects like a drunken sailor with a pocket-full of five dollar bills at a stripper bar. Meanwhile New Brunswick, already sitting on the best reactor design in the world, started flirting with the French.

And hanging over everyone's heads, the long-promised break-up and partial sell-off of AECL: the flagship of the Canadian nuclear enterprise, the brain trust of CANDU design, the historical heart of "Canuke know-how", the place of Nobel Prizes and superconducting cyclotrons, the quintessentially Canadian general that led an army of quietly competent Canadian companies into world-wide battle for neutron share - and succeeded beyond most expectations… the True North Strong and Nuclear in the flesh… was now in the hands of a government that had heard the word "nuclear" far too often for its own comfort during its tenure.

But even now our seeds of optimism find purchase: The NRU, formerly invisible and now known to most Canadians, was diagnosed and repaired by the very multi-faceted R&D infrastructure that makes Chalk River Labs an indispensable jewel.

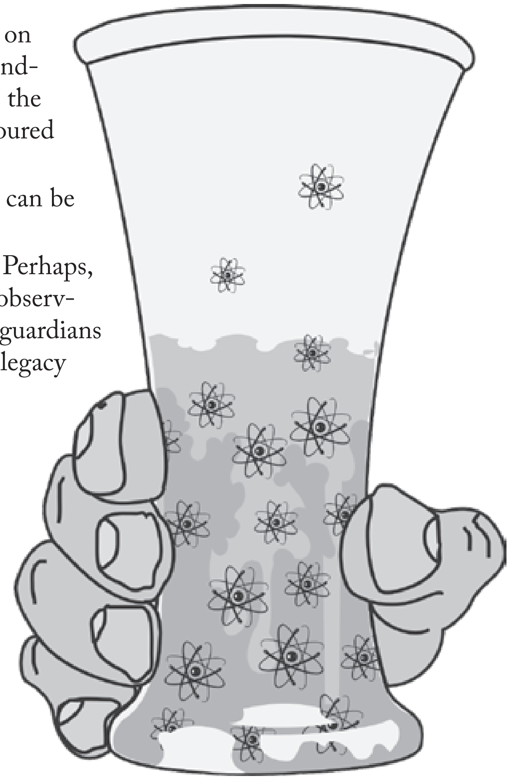
Refurbishments break new ground every day, and provide aging management lessons that are years ahead of any other reactor design.

Provincial wariness on new-build is understandable, and flirting with the French is a time-honoured Canadian tradition.

And finally, change can be good.

Eternal optimists? Perhaps, but we prefer "astute observers", ever the vigilant guardians of Canada's scientific legacy are we.

After all, it's not whether the glass is half empty or half full - it's the second-derivative of the boundary between the two that's important.



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