CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

MARCH 2009 MARS VOL. 30, NO. 1

- CNA Conference Largest Ever
- 30th Anniversary of the CNS
- CANDU Maintenance
- Special Session of Council

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Have you been Green-Winked?

The McGuinty Government just released its Green Energy Act. It contains no surprises given the long-standing tradition of politicians pleasing the voters to gain popularity. Who could possibly NOT support "green" initiatives? Everyone cares for our planet. Everyone is concerned about climate change. Everyone would strive for the utopia of clean air, clean water, and clean energy. There is now a very strong public perception that the "green" initiatives will result in a healthier planet whilst still having their morning toast and hot coffee. But just how "green" is the Green Energy Act?

The Green Energy Act sets the way to fast-track development of giant wind turbine farms across our pristine landscape. But because the wind fluctuates, natural gas has to be burned to stabilize the grid. Natural Gas, of course, is an emitter of Green-House Gases (GHG). This is also true with solar power since sunshine varies. Solar power is very costly on a large scale, which is why the Government will pay ten times the average grid price for solar-based electricity in order to make solar development attractive to investors. Of course, solar panels on your rooftop will get you a hydro rebate. Rooftop solar collectors make sense in low-rise, large area buildings that are costly to heat (such as the solar collection system used at AECL's Whiteshell Research facility, which saves a few hundred thousand dollars per year in heating costs). However, solar is simply impractical for large-scale generation needed to supply the grid. So I don't see any reduction in GHG reduction with wind and solar, just fewer "green-backs" (dollars) in my wallet.

How about renewable bio-fuel? Certainly there is no reduction in GHG when bio-fuels are burned instead of coal. Furthermore, production of bio-fuels diverts our grains from food supply to electricity supply. Is this a good idea? Is it even ethical? Perhaps it is good for farmers to have another "customer", but is it sustainable in an ever-hungrier planet where food shortages prevail in places? Because there are other options for electricity supply, grains might better be exported to where food shortages exist through means of better foreign aid policies.

Some argue that wind and sunshine are free. But you and I will pay 11 and 44 cents/kwh for wind and solar generated electricity, compared to about 5 cents/kwh for our current supply mix (wholesale cost not including distribution, local utility costs and taxes). The move to decentralize generation with a distribution of small generators has its costs as well, $5 billion according Smitherman, and probably more.

Clearly what is portrayed as "green" is not really green and the politicians have cashed in on a population that has been hoodwinked (or green-winked) by coercive utopians who claim to be environmentalists.

Nuclear energy, and in particular the Canadian designed and built CANDU reactor has proven itself to be extremely safe (can't say that about the food industry with their Listeria outbreaks, or the propane industry that allows illegal and dangerous truck-to-truck transfers), extremely reliable (can't say that about the transportation industry or automobile manufacturing) and extremely cheap (only hydroelectric energy is cheaper and as discussed above, wind, solar and bio-fuels are not cheap at all).

Have you been green-winked?

In This Issue

Spring has arrived and so has the 30th Anniversary of the **Canadian Nuclear Society**. We include in this edition of the **Bulletin** a report on the special session of the extended council held to collect thoughts and opinions about the CNS, its values and vision, which sets the building blocks for a new strategic plan that looks to where we want to go. **Fred Boyd** describes the 30-year history of the CNS, which looks at how we got to where we are.

Also of the "30th Anniversary" category is the accident at **Three Mile Island**. We have taken a look back at the perceptions at the time and reveal how an interesting sequence of learning events took place. We learn that popular perspective, although convenient, is not always correct and things may not be as they seem. Also, after the ditching of an aircraft on the Hudson River, we understand better the difference that a **good operator** can make.

Neil Alexander continues to write about the readiness of the CANDU industry and we have two conference reports – the CNA's **2009 Nuclear Industry Conference and Trade Show** (largest ever!) and **6th Annual Conference of Women in Nuclear** (WiN).

There are three technical papers on ***CANDU Maintenance*** and the regular news sections. And always provocative and entertaining, **Jeremy Whitlock** offers a dark and chilling tale in ***Endpoint***.

We hope you enjoy! As always, letters, articles and comments are welcome.

The past few months have been an active time for the CNS and for the Canadian nuclear program in general.

The Society

In mid January the Society held a "Special Session" of what has been called the "extended Council" *(See the report by* editor *Ric Fluke in the CNS News section.)* The intent of that event was to establish those, now common, building blocks of an organization; a vision, a mandate, goals, which would provide the basis for developing a five-year strategic plan.

Although the intent was not fully achieved, partially because the facilitator lost her voice midway through the day, there was animated discussion among the fifty participants about the purpose and role of the Society. Their thoughts were recorded and are currently being reviewed.

In parallel, Council is still debating the recommendations of a Task Group on the organization of the Society. The most contentious recommendation, made in the recognition of the growth of the Society over the past few years, was the appointment of an Executive Director. Eric Williams, our Past President, has taken on the task of obtaining a consensus on which recommendations should be adopted. If, as a member, you have any views on such a move, send them to him.

The Annual Conference

If you have been reading the Bulletin or looking at the great CNS website you know that the Society is holding its Annual Conference in Calgary.

When the decision to go west was made, almost two years ago, it was recognized that it was bold and challenging move. The current concentration of nuclear activities, especially related to nuclear power, is in the east and most of the members of the CNS are in the east.

As for most CNS activities, the organization of the conference is being conducted entirely by volunteers, under the very capable leadership of our 1st Vice President, Dorin Nichita. The program is well in hand, including a special group of presentations under the title of "Western Focus" with topics specifically related to potential nuclear developments in Alberta and Saskatchewan. Already, space is becoming tight at the conference hotel. If you have not made plans to attend, do so soon.

The Canadian nuclear scene

The major event of the past few months was the Annual Conference of the Canadian Nuclear Association *(also reported in this issue)*. It reflected an optimism that a "nuclear renaissance", is almost here.

However, at the same time anti-nuclear forces were very active, and, in my opinion, the nuclear community has responded very poorly, with one, somewhat unlikely, exception.

In February the Chalk River Laboratory released a small quantity of tritiated heavy water. The health and environmental effects were infinitesimal. Nevertheless, as has become mandatory in the nuclear community, the event was reported openly. No other activity is subject to this scrutiny. Various "environmental" groups jumped on the reports and obtained much media coverage with their outrage about the "trillions" of becquerals of tritium going into the Ottawa River. *(A "becqueral", for the uninitiated, is one radioactive disintegration per second – a ridiculously small unit of measure.)*

As well as the excessive media coverage, a special meeting of the House of Commons Standing Committee on Natural Resources was held with witnesses from CNSC and AECL. Who provided clear, concise answers? Not the representatives of the organization that caused the release but the regulator, CNSC President Michael Binder.

Communication

Which brings me to what I consider a major (and dangerous) failing of the nuclear community over the past year or so. Its lack of effective communication with the public. Every day in newspapers across the country there are articles and letters screaming about the evils of nuclear plants or the dangers of radiation.

The voice of the industry, the CNA, has been silent for over a year. Perhaps that is why, according to their own polling organization, public support for nuclear power has slipped to only 48% while that for "renewables (wind, solar) is over 90%.

Within the CNS there has been much debate about the Society issuing "statements" with many members arguing that, as a society of individuals, it would be impossible to obtain a consensus on any topic.

That does not stop individual members speaking out. Admittedly, those working for prominent nuclear organizations may be reluctant and may be perceived as being biased. So, this places a challenge on academics and retirees, especially the latter. If the category fits, warm up your keyboard and send out clear, positive, preferably concise e-mails (or even "real" letters).

Just possibly we can convince a majority of the public that nuclear science and technology and their applications are great benefits to us all.

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~ Cover Photo ~

View of the Point Lepreau Generating Station.

– Photograph courtesy of New Brunswick Power.

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Will the lights be on in 2027

Re Editorial in the 2008 December edition of BULLETIN, "Replacing Nanticoke: Truth against the wind?"

Indeed Minister Smitherman should re-think his plan and he should also give some assurance that it will work to keep the lights on through to 2027. In August of 2007 the Ontario Power Authority (OPA) filed an application for approval of it's Integrated Power System Plan (IPSP) and certain procurement processes with the Ontario Energy Board (OEB). The plan was supposed to ensure that Ontario has, what the politicians of the day considered, an appropriate generation mix to take it through the next 20 years of coal phase-out, nuclear refurbishment, and new nuclear build. However the OPA is only responsible for medium to long term planning for new generation and is not responsible for the day-to-day operation of the province's power grid. This is the responsibility of the Independent Electricity System Operator (IESO). Unfortunately the operating window of the IESO is from current to short term so it cannot really say today how the generation assets it has been given by the OPA are going to fit together 15 or 20 or more years down the road. The IESO tries to give some assurance that the grid will be working up to 18 months ahead by issuing regular outlooks and the IPSP will be updated every three years, which may indicate the level of confidence the OPA has in it's plan. The IPSP can be tinkered with only so many times before it falls apart.

Case in point is the government-mandated replacement of coal-fired generation by a combination of natural gas-fired generation and wind, and a 14,000-megawatt limit on nuclear. Right now the wind generation is supported by coal and gas and after 2014 by gas since coal will be phased-out. There is far too much reliance on gas. Twenty years from now, or even sooner, gas may not be available because of concerns about post and pre-combustion greenhouse gas emissions, air pollution, high unit energy cost to consumer, dollar cost of carbon, security issues of foreign supplies, high demand for gas from the United States, gas demands of tar sands, declining gas reserves, lost gas legacy to future generations, home heating demands, gas as feedstock to the chemical industry, or, in short, the waste of a premium non-renewable resource just to generate electricity. Eventually gas will have to be treated as a transitional fuel that would be restricted to space heating using high efficiency furnaces or co-gen, to be superseded by nuclear/hydro generation and ground source heat pumps. For more uncertainty, by 2027 there could be significant electric motor vehicle battery charging demands on the grid. Not all this charging demand will occur during the ideal off peak overnight hours, some of it will be added during the day and to the late summer afternoon peak. There may also be climate change affects reducing the hydroelectric supply.

Studies conducted for the IESO/OPA to show that wind can be integrated into the Ontario grid would have assumed the continued availability of gas-fired generation. Without gas-fired generation wind would be a hindrance to the reliability of the nuclear/hydro power grid rather than a help even if additional nuclear and hydro were available in time to avoid blackouts.

Back in September of 2008 the Minister of Energy and Infrastructure, George Smitherman, requested the OPA to take a look at increasing the amount of renewables, conservation and distributed generation in the IPSP, essentially more wind to a plan already heavy in wind. This means that the OEB, which had geared up to review the IPSP, had to stop work and is now waiting for the OPA to release the revised plan.

So, who has the responsibility for ensuring that Ontario's power grid will be operating reliably 20 years from now? We have Ontario Power Generation, the IESO, the OPA, Hydro One, the Ministry of Energy, and still no assurance that the lights will come on 20 years from now. Remember that the IESO and the OPA are both governed by Boards of Directors appointed by the Minister of Energy, a common mode failure which might explain their enthusiasm for wind. Let us hope that when the OEB (Board members are appointed by cabinet and report to the Legislature through the Minister of Energy) reviews the OPA's plan it will see this IESO/OPA dichotomy and recommend that just one organization be responsible for ensuring that power is available when needed, at any time in the future. Of course it would help this one organization if it did not have to deal with the gas and wind combo that will have been foisted on it by the government, whoops, sorry, I mean by the OPA. The billions being invested in wind, and gas, could be better spent elsewhere.

Don Jones
Mississauga, Ontario

*[**Ed. Note:** Don Jones is a CNS member.]*

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On the Importance of IP to the future of our industry.

By Neil Alexander, President, Organization of CANDU Industries

My inspiration for this article is drawn from a Globe and Mail cover story in the January 17 edition of the Report on Business. The article is titled "Canadian Innovation" and is about the tragic loss we experience when companies like Nortel collapse. The lead in to the article says "*Nortel has stumbled into bankruptcy and there are few stars to take its place. How Canada lost its edge as a technology incubator*".

This article raises many issues that we in the nuclear industry must address. Key among them is why CANDU never gets a mention. The article features photos of, the Arrow, Imax, the Canadarm, and the ubiquitous Blackberry along with a couple of other devices that I didn't recognize. But no CANDU's. Clearly we must talk at some point about how we as an industry have failed to attract positive attention while managing very well at becoming a lightening rod for anything bad. But that will be for another time.

Instead, I would like to build on a key theme of the article as quoted by Mr. Chowaniac (a former Nortel researcher who is now a Chairman and Investor in five high-tech companies) *"Tech Giants are like anchor tenants in a mall"* and *"you cannot build a knowledge economy without significant anchor companies like Nortel"*. The article goes on to conclude that *"there are no new Nortel's – companies able to serve as role models, funding sources and training academies- in the pipeline"*.

Wait a minute - what about AECL!? It may not be a new company but it is one of the countries largest investors in R&D and a training ground for many of us (hold your hand up now everyone that has spent at least some of their time working for AECL). AECL is a tech giant and a wonderful anchor tenant for "the mall" in which OCI's member companies are clustered.

AECL has its problems but just look at what it does in terms of enhancing Canada's industrial capabilities, developing technologies, creating opportunities and training us so that we can set-up new service, design and technology companies of our own.

The key to this success is Intellectual Property or IP. When AECL works with Canadian companies it creates IP for itself from which we as a shareholder benefit and it also creates IP that our companies use. We have wonderful examples of where working with AECL has given a company or an individual IP that has then been used to sell to other reactor designs, the aerospace industry, pharmaceuticals and even the automotive industry.

And although nuclear is not a brand new technology, there is without doubt a renaissance taking place. In the early 2000s almost no money was being spent on new reactor construction. In 2009 hundreds are on the drawing board at billions of dollars a piece. What other industry, even a new one, is experiencing this rate of growth? In business a dollar made from a renaissance technology looks exactly the same as a dollar made from a new technology. And a man-hour of employment is still a full 60 minutes worth of work to the guy on the shop floor.

There are of course other anchor tenants in the Canadian nuclear mall. OPG, Bruce Power and the other power generators certainly have a valuable place providing routine ongoing business. But it is AECL that puts us on the world stage and it is on the world stage on which the nuclear renaissance will largely play out.

So if Mr. Chowaniac is correct and there are no new Nortel's, let us make sure we keep the tech giants we already have – like AECL. You cannot build a knowledge economy if you do not have any knowledge to build it on!

Artist's concept of a twin unit ACR-1000. Courtesy of AECL.

KEY QUESTION FOR THE FUTURE

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Is the nuclear renaissance at hand?

by Fred Boyd

Judging from the attendance at the Canadian Nuclear Association's **2009 Nuclear Industry Conference and Trade Show,** February 25 –27, 2009, one would think that the renaissance of the Canadian nuclear power program had begun. A record breaking 735 representatives of almost every company and organization involved (or hoping to be involved) in the Canadian nuclear program were present, with the notable exception of Atomic Energy of Canada Limited.

Among the delegates were 93 students from 15 Canadian universities. Wardrop Engineering Inc. sponsored 38 engineering students; AMEC NSS Ltd. sponsored 30 from science and physics programs and the Society of Professional Engineers sponsored 25 from Carleton and Ottawa universities.

Held again at the Westin Hotel in Ottawa, the event, previously called Nuclear Industry Seminar, required the entire fourth floor of the hotel to accommodate the large number of exhibits. As a security measure, once the exhibits were set up on the afternoon of the Wednesday, February 25, the elevators were stopped serving that floor.

Following the pattern of recent years, the conference offered an eclectic series of interesting speakers interspersed with ample breaks to accommodate time to visit the exhibits, enjoy the ample refreshments and do the desired net-working.

An almost lavish reception, hosted by AREVA, opened the event on the Wednesday evening. Gracing the party and bringing greetings from the federal government was the recently appointed Minister of Natural Resources Canada, **Lisa Raitt.** Her encouraging message and engaging manner provided a positive note to begin the conference. She began with the comment that on her first day in the position she was asked "What are you going to do with AECL ?" Referring to her noon hour talk to the WiN Canada conference *(See separate report)* she noted that women occupy four important nuclear roles; herself, her deputy, the chair of AECL and the chair of AREVA. "That means something will be done", she stated. *(Extracts from her talk are printed elsewhere in this issue.)*

Lisa Raitt

Pierre Charlebois

Dr. Brian Cox

Richard Cortright

The conference proper began at breakfast early the next morning with a welcome and introductory remarks by **Pierre Charlebois**, CNA chairman and Executive Vice President of Ontario Power Generation. There is a danger of over-enthusiasm, he warned. Although refurbishments are proceeding at Bruce and Point Lepreau, Darlington has been selected for two new units and other developments are underway, we are in a difficult economic situation, he noted. We need a strong and capable regulating system; and successful completion of the refurbishments, he said. The industry must work together to gain public support and, he emphasized, must operate our nuclear plants safely and successfully.

The breakfast speaker was Senator **Hugh Segal**, *former Chief of Staff to the Prime Minister of Canada and Associate Secretary of the Ontario Cabinet*, who titled his address as: *Understanding Why the Costs of Nuclear Inertia Far Outstrip the Risk of Moving Ahead with Nuclear Development Now: A Time for Tough Choices.*

> Segal: "The costs of delay are staggering"

After referencing some of the nuclear reviews in Ontario and the decision to build Darlington he stated: "If sustainable energy sources, tied to both our national security and economic and social requirements are to be genuine priorities for Canada, then a serious national program of nuclear power construction must be an overarching national priority. The costs of delay are staggering, and they far outstrip the costs of proceeding now."

Moving into the conference proper, the first speaker was Dr. **Brian Cox,** from the CERN laboratory in Switzerland, who titled his presentation, *The Large Hadron Collider at CERN: Exploring the Forces of Nature Inside the Atomic Nucleus***.**

He began by commenting that the work at CERN is a continuation of the journey to understand the structure of matter that began with the work of Ernest Rutherford at McGill University a century ago. The 27 km long Large Hadron Collider (LHC), he said, is by far the largest and most complex scientific machine ever built. The focus of the machine, he said, is the quest for a deeper understanding of the behaviour of the strong and weak nuclear forces in the extreme conditions that existed less than a billionth of a second after the universe began. With a number of slides, some quite complex, he attempted to try to convey the current understanding of matter.

The following speaker was from a far different world. **Richard Cortright**, Managing Director for US Utilities and Infrastructure Ratings at Standard & Poor's, of New York, spoke on *Assessing the Credit Risks for New Nuclear Power Plants.*

Speaking entirely of the US context, he described Standard & Poor's method of analysing the credit risks faced by US utilities. Their analysis focuses on the technology risk, the uncertainty of construction costs, liquidity requirements and the evolving regulatory framework. At the beginning of the last major generation construction cycle in which utilities were the principal participants, the debt ratings of utilities were in the AA and high A category. They were

well positioned for the major financial pressures to come. Today, in advance of a major capital expenditure period, ratings are much lower.

Construction poses the greatest credit risk, he said. Construction risks arise from:

- Cost inflation in input materials: somewhat down recently, but still volatile
- Supply chain bottlenecks
- Unavailability of engineering, procurement, construction contracts; uncertain labor cost
- A limited construction record
- NRC supervision process

Further, he noted, the track record for construction is limited.

- Only the ABWR has been built and put into operation
- Modular, open top construction will reduce field work but the challenge will be to successfully train technicians and transfer skilled labor productivity to the USA
- Delays can happen for a variety of reasons (Olkiluoto, Lungmen)

Finally, there are uncertainties of the regulatory process at both the federal (NRC) and state levels.

After the coffee break, the delegates heard **Michael Binder**, President of the Canadian Nuclear Safety Commission speak on *Nuclear Regulation in Canada – Moving Forward*. Binder, who was appointed head of the CNSC just over a year ago after the NRU and medical isotope crisis, began with noting the world's energy demand and the role of nuclear. Then he turned to his now common description of the CNSC as "Canada's nuclear watchdog" with a slide to depict that.

Michael Binder

Brad Wall

Angie Howard

He noted the following mention of nuclear regulation in the Throne Speech at the recent opening of parliament.

"Nuclear energy is a proven technology, capable of reliable, large-scale output. In Canada and around the world, energy authorities are investing in nuclear power to meet both energy security and climate change goals. The Government of Canada will ensure that Canada's regulatory framework is ready to respond should the provinces choose to advance new nuclear projects."

That, he said, laid out a clear direction and expectation for the CNSC.

He described the CNSC as a quasi-judicial body that is independent of, but not isolated from, government. It regulates the use of nuclear energy and materials to protect the health, safety and security of persons and the environment; and to respect Canada's international commitments on the peaceful use of nuclear energy.

Noting that regulation of nuclear activities is a federal responsibility he stated that CNSC regulates all nuclear facilities and activities in Canada including:

- Nuclear power plants
- Uranium mines and mills
- Uranium fuel fabricators and processing
- Nuclear substance processing
- Industrial and medical applications of nuclear substances, such as nuclear medicine and cancer treatment centers
- Research and educational facilities
- Importers/exporters of nuclear-related dual-use equipment
- Waste management facilities

He closed by noting that CNSC needs to expand to meet the expected growth of the nuclear program in Canada and is looking for good people.

The guest speaker after the excellent lunch was **Brad Wall**, Premier of Saskatchewan. Titling his remarks as *Nuclear Industry Development in the New West* he began with a quote that "temerity brings more problems than audacity". Saskatchewan is a major supplier of uranium, he noted, but it wants "value added". He referred to the study by Bruce Power on the possibility of a nuclear power plant in his province and spoke of a uranium development partnership to look at additional opportunities. Although praising Michael Binder for his leadership in nuclear regulation he suggested that some of the regulatory power regarding uranium should be devolved to his province.

Beginning the afternoon session, **John Wright**, Senior Vice-President, Ipsos-Reid, presented an update on *Canadians' Attitude Towards Nuclear in Challenging Times.*

He noted that his company has been tracking overall support for and attitudes toward nuclear energy in Canada since 1987 and more extensively since a February 2005 benchmark. The latest survey was conducted by telephone January 19 to February 1, 2009. The total sample was 2,200, resulting in a margin of error of +/-2.1%.

In the recent survey, support for nuclear was down slightly from last year at 48% compared to 50%. (As a comparison, solar was 97%, wind 95% and hydro 91%.). Regionally, support in Ontario is the highest at 67%, lowest in Quebec at 28%. Support for refurbishment has remained strong, now 78%, with strong opposition at 13%. A majority of respondents, 54%, supported building new nuclear power plants now to create jobs and ensure the supply of electricity.

In conclusion, he said, Canadian public opinion on nuclear power is primarily positive and stable. Hard opposition has been whittled down from 41% to 28% in less than four years. Most Canadians believe that alternative sources of energy won't offset future demand and see nuclear as a critical and necessary part of the energy mix for the future. He cautioned that the support of today is, and always will be, soft, unless the need of this energy source for the future remains prominent. There must be a steady drumbeat of communication and dialogue with the public in order to ensure a sense of ***need and urgency, he asserted in closing.***

Another American perspective was presented by **Angie Howard**, Vice-President, Nuclear Energy Institute, under the title *U.S. Nuclear Energy – A Partner in Climate and Supply Options.*

She began by citing the performance figures for US nuclear plants which had a fleet capacity factor in 2008 of 99.1%, down slightly from the previous year but up significantly from a decade ago. Licence renewals continued with three granted in 2008 bringing the total of renewals to 51, half of the US fleet.

Regarding the progress toward new plant development she

noted that over the past two years there were:

- 3 early site permits granted (by USNRC)
- 3 designs were submitted for certification
- 17 applications for a Construction and Operating Licence (COL)
- 3 engineering and procurement contracts signed

A number of states have passed legislation to ease the financing and the Department of Energy has offered loan guarantees totalling $18.5 billion. However, there are now applications totalling $122 billion in loan volume. She quoted the new secretary of Energy, Steven Chu, as saying that a priority would be given to accelerating the loan guarantee program.

She praised the NRC for improvements in the licensing process and noted that suppliers were building or improving their capacity to provide components. There has been a five-fold increase in the number of students in nuclear related programs. Nuclear will contribute to President Obama's goals, she argued, but noted that sustained safe and reliable operation of existing plants is essential.

In closing she referred to the recent move to end work on the large spent fuel storage facility at Yucca Mountain. If it is terminated, new research and development will be needed on recycling, she stated.

Jack Keir

Rex Murphy

John Beaucage

The last speaker of the afternoon was **Jack Keir,** Minister of Energy, New Brunswick, who titled his address, *Adding Nuclear Capacity in New Brunswick: Refurbishment and New Construction at the Point Lepreau Generating Station.*

He began by referring to his presentation at the 2008 conference and his vision for New Brunswick - a New Brunswick that is a world-class energy hub for the international Northeast region. Today, he said, he wanted to focus on two energy mega projects in New Brunswick – the Refurbishment of the Point Lepreau Nuclear Generating station, and the ACR 1000 new build project.

New Brunswick intends to be not only a supplier of electrical generation capacity to Eastern Canada and New England, he stated, but also to develop sustainable industry clusters in a number of areas. Already, he said, the New Brunswick energy hub cluster includes over $20 billion in current, planned or potential projects, attracting the attention of a number of world-class companies.

Noting that Point Lepreau is currently undergoing the first refurbishment of a CANDU-6 reactor in the world, he stated that it is an impressive first for his province and a key to growing the energy hub.

The refurbishment project has resulted in the establishment of an international Centre of Excellence for the retubing of CANDU-6 reactors in Saint John, he noted. The Centre serves as a training facility for the more than 800 additional staff that are working on the refurbishment project. He noted that engineers and technicians had come to New Brunswick, from CANDU-6 plants in Québec, Korea and Argentina to learn about refurbishment.

He went on to talk about the progress of the Point Lepreau refurbishment project. Commissioning of some of the high tech refurbishment tools has been challenging and the project has experienced some delays, he acknowledged. However, he stated, the team at Point Lepreau is committed to recover as much time as possible on the schedule.

Then he turned to the possibility of a second nuclear power plant at Point Lepreau, an ACR – 1000 and referred to the $2.5 million study by Team CANDU in 2007/2008 that confirmed the business case and overall project viability of an ACR-1000 nuclear generating plant at Point Lepreau that would supply clean electricity to the Maritime provinces and New England.

This would be a private, not provincial, investment, he stated in closing, with NB Power operating the plant.

The final day also began with an early breakfast followed by a talk by **Rex Murphy**, the erudite and acerbic commentator of CBC radio and TV, who had titled his presentation as *Politics in Ottawa and Climate Change*.

He began with a reference to his office in the CBC building in Toronto, which he dubbed as a "shrine to Bishop Suzuki". Any relationship of CBC to journalism, he quipped, was like that of a streetwalker to highways. Among the several stories with which he began was one about the "cucumber enterprise" in Newfoundland, his home province, which was so ridiculous, he said, that only a government could do it.

Turning to an overview of "environmentalism" he emphasized his love of nature and concern for the environment. However, he said, environmentalism had become a belief, making it difficult to question global warming. If [global warming] is true, he said, the answer was in the room – nuclear power – but "environmentalists" say "no". It is a fundamental *non sequitur*, he stated. We must separate advocacy and science, he said in closing, and was greeted with extended applause.

The first of the day's conference presentations was given by **John Beaucage**, Chief of the Grand council of the Anishinabek Nation of the Union of Ontario Indians, speaking on *First Nations Involvement in the Energy Industry.*

Emphasizing that he supports change and development and has a respect for science, he stated that there are things that are still not known. The native tradition is that all things are related, he said. Energy can be a source of income for native groups, he acknowledged, then referred to discussions with Ontario Minister of Infrastructure, George Smitherman, in which he had insisted that first nations be involved in matters such as transmission lines and location of wind farms. Treaties are sacred, he stated, which means there must be sharing of resources. The environment must be respected, he emphasized in closing.

The final topic of the conference was titled *Strategic Leadership in Nuclear* with two presenters, **Ian McGinty**, Executive Vice President, Human Resources, Bruce Power and **Lewis Rusen**, Senior Partner, Leadership and Talent Consulting, Korn/Ferry International.

McGinty began by referring to challenges Bruce Power faces regarding its staff. He identified them as: retirement; diversity;

expectations; misalignment. Sixty percent of Bruce Power's staff are eligible for retirement in five years. Referring to the Women in Nuclear meeting on the Wednesday, he acknowledged that Bruce Power is not doing enough to truly engage women.

Then, as background he showed a video of Bruce Power's president, Duncan Hawthorne, speaking in 2007 about joining forces with Korn/Ferry International on a program of: integrated talent management; leadership development; recruitment. Before turning the microphone over to his partner he proclaimed, "We need lots of people, now".

As an example of talent management, Rusen noted that McGinty had joined Bruce Power just a couple of years ago from Johnson and Johnson, a company in a completely different industry. He referred to discussions with Hawthorne and staff to clarify what was wanted and needed. Korn/Ferry assigned a team to work with Bruce Power people. Good things have been accomplished, he said, but much more needs to be done.

In closing the presentation part of the conference, CNA President, **Murray Elston**, thanked his staff, especially **Claudia Lemieux**, the primary organizer, and thanked the sponsors and exhibitors. He noted that the exhibits would remain until well after the buffet lunch.

All of the presentations are posted on the CNA website, along with video recordings of the actual presentations.

The sponsors and exhibitors were: AREVA; Ontario Power Generation; Bruce Power; Power workers' Union; Cameco; GE-Hitachi; Hitachi; E.S.Fox; Comstock; Wardrop Engineering; The Society of Energy Professionals; AMEC; Babcock & Wilcox Canada; RCM Technologies Canada; Powertrain; Worley Parsons; Black & McDonald; L3 communications; ATS Automation; Nuclear Waste Management Organization; Kinectrics; Nuvia; Hatch, Sergent & Lundy; Hydro Québéc; SNC-Lavalin Nuclear; BPR; McMaster University; Canadian Union of skilled Workers; Promotion Engineering; Ian Martin; AECON; Canadian Nuclear Safety Commission; ANRIC; Canadian Nuclear Society; Amandine; Industrial Audit; SWI; UOIT

Excerpts from notes for NRCan Minister Lisa Raitt' address to CNA Conference 25 February 2009

As a Canadian, a scientist and as the Minister of Natural Resources, I have to say that I'm incredibly proud of this country's nuclear industry.

We've been a pioneering innovator in the developments of nuclear technology, and we've distinguished ourselves by harnessing this technology and ensuring that it's operated safely and reliably at home and in other parts of the world.

We're a world leader in applying nuclear technology in areas such as medicine, food safety, in agriculture and in manufacturing processes.

And keep in mind, our nuclear agenda includes uranium, and as everyone in this room will know, Canada's the largest uranium producer in the world.

As you are aware, there have been several small heavy water leaks at the NRU recently that were well below the CNSC's threshold for a public announcement.

It is vital that the industry fully recognizes the value of transparent public communication.

I'm very pleased that AECL and the CNSC are reviewing their public communications protocols, and I thought they did spectacularly well in front of the House of Commons committee [February 24] with respect to these matters.

I can't talk about health and safety in the nuclear industry without mentioning the other part of my favourite file, medical isotopes.

AECL took a difficult but a responsible decision last year in ending the Maple project. We are now moving forward in the pursuit of an extension of the NRU licence beyond 2011. It is important to recognize, however, that securing a long-term supply of medical isotopes is a global issue and requires a global response.

Last month, at Canada's request, a nuclear energy agency meeting on the security of isotope supply was convened in Paris. The meeting brought together representatives of government, industry and the nuclear medicine community to discuss global solutions concerning the ongoing supply of medical isotopes. Eighty participants from 16 countries participated in the global dialogue. There's strong support for the creation of a new working group of the Nuclear Energy Agency to carry this international agenda forward. Indeed, it is understood that governments must help establish conditions that will allow the best solutions to emerge.

A strategic review of AECL is underway. Our objective in this process is to position the Canadian industry to grow and compete for its fair share of the opportunities in Canada and around the world.

After that review was launched last year, the government of Ontario issued a request for proposals for the procurement of new reactors. AECL is participating in this process.

We can all agree that the respective outcomes [of the two processes] will have a considerable influence on the future shape of the nuclear industry in this country. And no, I'm not going to tell you what the decision is. You'll have to wait; it's like at the end of the book — you don't flip to the back of the book to get to know.

WiN Canada holds 6th conference

by Fred Boyd

About 130 members of Women in Nuclear Canada gathered at the Chateau Laurier Hotel in Ottawa on February 25, 2009 for the sixth Annual Conference of the organization. As for the previous conferences this was timed to precede the annual conference of the Canadian Nuclear Association.

A number of the delegates had participated in technical tours the previous day. Visits had been arranged to: AECL's Chalk River Laboratories; MDS Nordion in suburban Ottawa, GE/Hitachi Nuclear Energy Canada in Peterborough and NuTech Precision Metals Inc. in Arnprior.

The organizers chose an interesting and challenging format – with most of the day devoted to 10-minute presentations. Remarkably, all of the presenters met the challenge and the event went off on schedule.

Following a continental breakfast, WiN Canada President, **Susan Brissette,** of Bruce Power, introduced **Glenna Carr,** Chair of the Board of Atomic Energy of Canada Limited, who opened the conference by sharing personal anecdotes and offering career advice.

Following the address by Ms. Carr, **Cheryl Cottrill,** Executive Director of WiN Canada, introduced **Jeremy Whitlock,** former President of the Canadian Nuclear Society, in his role as a nuclear historian. With the title of *Splitting Atoms Canadian Style* he provided what he described as " a whirlwind tour through 100 years of nuclear innovation in Canada".

Then began the series of "mini-sessions".

Just before lunch the delegates clustered together for what has become a WiN Canada tradition, a photograph of the entire group.

After lunch the recently appointed Minister of Natural Resources Canada, **Lisa Raitt,** motivated the attendees with a very humorous and inspirational look at her own personal career journey. She expressed support for WiN and positive thoughts on the Canadian nuclear industry. Minister Raitt was quick to point out that three of the top positions in the industry are held by women, herself as Minister of Natural Resources Canada; Cassie Doyle as Deputy Minister of Natural Resources; and Glenna Carr, Chair of the AECL Board.

After lunch the "mini sessions" continued for an hour at which time there were five–minute reports from the five WiN Canada Chapters.

Following the afternoon break, **Angie Howard,** of the Nuclear Energy Institute of the USA, and chair of WiN US, presented an invitation to delegates to attend the WiN Global 2009 Conference which WiN US is hosting in Washington D.C. in July.

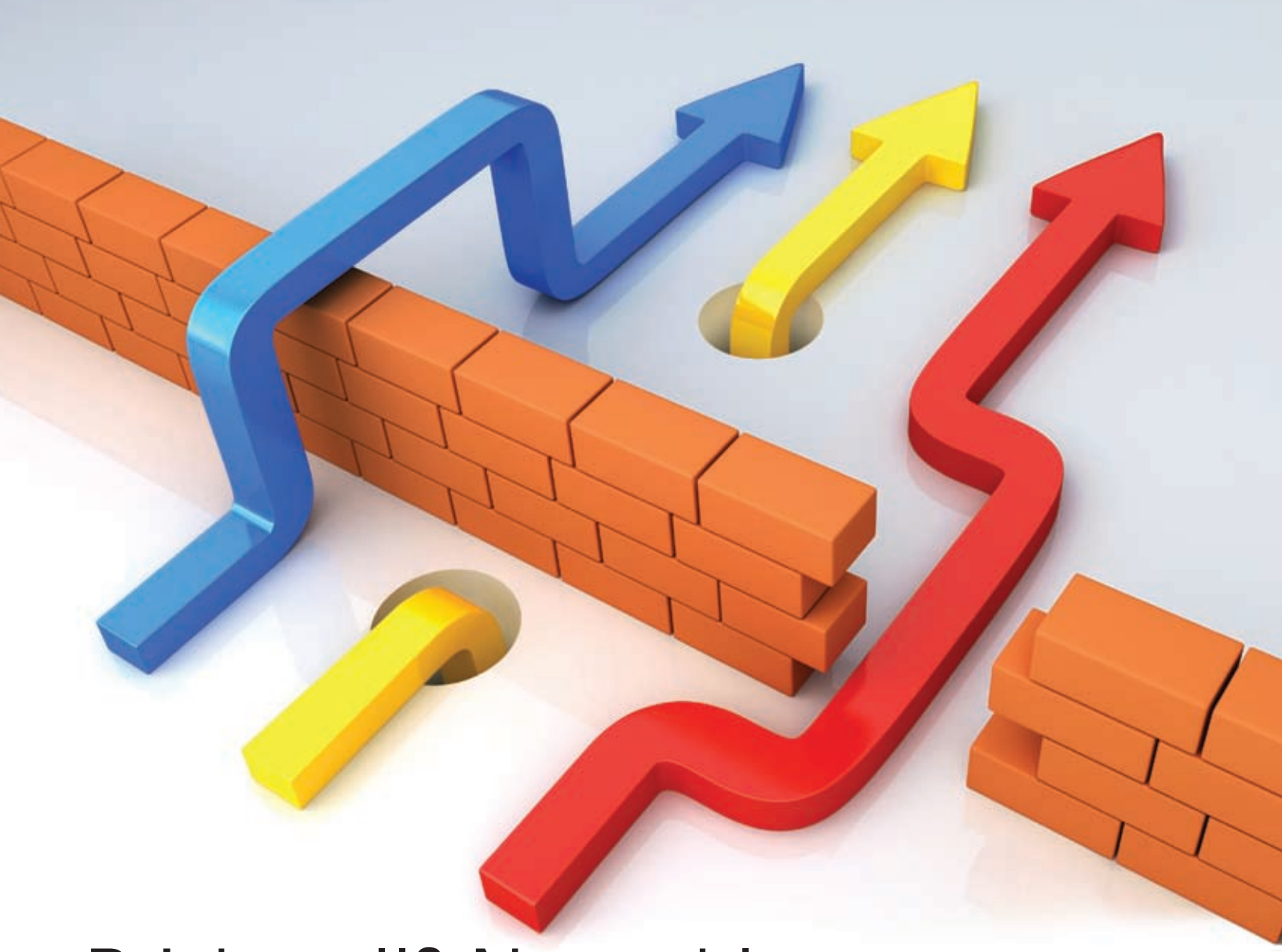
She was followed by **Elise Herzig,** consultant to McMaster University who explained how women can learn to inspire, engage and connect through story telling. Include the five Ws (who, where, what, when, why) and "how" in the message, she advised.

The last of the short presentations was by **Sherri Gillanders,** of OPG, who described the *"emPOWERed Women Program"* at her company. This is a new leadership development and mentoring program designed to help women employees build a support network and develop leadership capabilities.

Closing the event was **Adele Alfano,** an author and motivational speaker who titled her presentation as, *"I'm Not Tense – Just Terribly Alert"*. Animated and humorous, she encouraged her audience to embrace a culture of change and not to take life and work too seriously.

All presentations, supplementary papers and pictures are now on the WiN-Canada website at www.wincanada.org.

Most of the delegates at the 6th WiN Conference join for the traditional group photograph.



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The TMI Accident: Thirty years later things are not as they once appeared!

By Ric Fluke

It was 4:00:36 am, March 28, 1979. This time-stamp will be remembered in history as the pivot point of nuclear power development, which led to a downward spiral in the nuclear power industry word wide. The sensational headline tabloid "The National Enquirer" called the accident a hoax – they said it was a Hollywood plot to promote their latest movie "China Syndrome". Not an unreasonable conclusion since, from the outside, it looked perfectly normal. The accident at Three Mile Island was, however, very real and serious. It was more significant to the industry's decline than the Chernobyl accident six years later because Chernobyl was viewed as a failure of the former Soviet Union to "handle high tech", not true but a view nevertheless held in Western countries. TMI was the event of the century that caused many countries such as Sweden, Italy and Germany to abandon their current programs. Other countries kept their current fleet but stopped development of future nuclear energy.

Thirty years later the industry is rebounding. Italy and Sweden have reversed their moratoriums and other countries are staring reactors previously shut down. Many more countries including Canada are planning new build.

There are significant differences in the manner in which the industry is rebuilding itself, particularly with respect to safety culture and the role of the operator. Safety culture suggests that operator error as a cause of an accident is over simplifying the event and that the institution has a large influence on how the operator responds – training, design, documentation, human factors, complacency, and indeed encouraging reporting of deficiencies and fixing them rather than living with known problems – these are all human activities that have an influence on how the operator responds.

Case in point – at TMI the steam generator feed pumps tripped, caused by a single error in maintenance while working on the Condensate Polisher. Immediately the emergency feed pumps started but their discharge valves were closed, another single maintenance error. The control room operator was unaware that the feed valves were closed because a maintenance tag covered the indicating light, a human error. The resulting power-cooling mismatch caused the reactor pressure to rise and the Pilot Operated Relief Valve (PORV) opened. The relief was insufficient to arrest the rising pressure and the reactor tripped on high Reactor Cooling System pressure. This resulted in shrinkage and the pressurizer level began to drop as expected. The operator "closed" the PORV and the indicator light indicated that the PORV had closed, but it had not. The indicator light only acknowledges that a command was sent to close the valve, but it does not indicate its actual position, a human error at the design stage. But let's park the "human errors" for a moment.

The accident at TMI resulted in core damage far more severe than had been predicted for design basis accidents, prompting

the US NRC to invoke a program of rule making. On the other hand, radioactive iodine (I^{131}), the chief radiological hazard in a nuclear accident (popularized by the massive 20,000 Ci release in the 1957 Windscale accident), was not released, again contrary to popular predictions of iodine behaviour in a severe accident, showing that the safety analysis codes were wrong. The reported release from TMI was a theoretical calculation since the release, if any, was too small to measure. Every scientist had their pet explanation and many joined the notion that the form of iodine is a non-volatile salt (CsI), and this notion "explained" the lack of iodine release at TMI.

Not everyone "bought" this "convenient truth". Canadian R&D programs, sponsored by Ontario Hydro and conducted by AECL focused initially on kinetic and equilibrium chemistry under classical (non-radiation) conditions. There was of course the usual "red herring", in this case, hydrazine. Hydrazine is effective in reducing iodine volatility in spent fuel bays when defective fuel is discharged (as documented in station event reports), and theoretical calculations based on classical chemistry supported the effect. Iodine volatility was extremely low at TMI and hydrazine was continuously being injected into the water pool inside containment. Another "aha". It was convenient to jump to the conclusion that hydrazine controls iodine volatility, and sadly, Ontario Hydro installed hydrazine injection systems for post-LOCA control of iodine. In retrospect, it was balderdash and a waste of time.

The radiation fields inside the TMI containment were enormous and it was postulated that classical chemistry might not apply under such conditions. In the late 1980s Ontario Hydro initiated a new R&D program to understand such conditions and their effects on iodine volatility. It was an aggressive "three-pronged" approach based on (a) theory (laboratory experiments and calculations), (b) "separate effects" bench-scale scoping tests (to focus on plausible explanations), and (c) integral "all effects" tests (to include intense radiation, realistic water chemistry, and realistic containment materials – paint, grease and grime, cleaning solvents and known organic materials commonly used in containment). In addition to AECL, Ontario Hydro engaged experts from the University of Toronto, the UK Atomic Energy Authority at Harwell, Siemens in Germany and the US Electric Power Research Institute. The program paid off handsomely and the results are now in service supporting the safety case for several reactors, including Sizewell B in the UK, and others around the world.

The answer is simple – the way to control iodine volatility in a high radiation environment with typical "greasy grimy" water is to have a high pH, 9 or higher, which coincidently is the normal coolant condition in a CANDU. This is not the case in a PWR, where the coolant is acidic due to the boric acid used to control reactivity. Thus, in the Sizewell PWR safety case, the containment sump (normally dry) is fitted with mesh sacks filled with dry chemicals that will dissolve in the floodwater after a LOCA and passively raise the pH.

So why does this make TMI a more interesting story? We know that hydrazine had nothing to do with the low iodine volatility. In fact, the reaction of radiation and organic materials produces acids that lower pH and would increase iodine volatility. The reason that iodine was not released was because of an unusual sequence of events and "human errors". The feared "hydrogen bubble" was released from the melted core into containment where it was ignited (by the telephone ringer) early in the accident. Ironically, it was the feared hydrogen burn that saved the world, or at least the residents of Pennsylvania from possible catastrophe. Why? The burn caused a pressure spike of 28 psig. The containment spray system design set-point is 30 psig but the operator had set it at 28 psig, a human error. Therefore, the sprays were initiated "in the nick of time" which washed out any airborne iodine and caustic material (NaOH) was injected with the sprays as designed, and this raised the pH of the sump water, thus locking in the iodine. The hydrogen burn also consumed oxygen, causing the containment pressure to become sub-atmospheric where it remained for a year.

Shortly after the accident many organizations jumped to conclusions and "preached" that TMI was a "success story" because despite severe core damage the radiological consequences were nil. Yes there were health effects, but they were the result of stress caused by media hype (local radio reported traffic, weather and radiation readings) and "radio-phobia", the fear of radiation instilled by "coercive utopians" that have hoodwinked so many ordinary people and continue to do so. It is all too easy to embrace the "convenient truth" but that is our lesson in history – things are not always as they seem!

Thirty years ago today an event took place that changed the world as we knew it then. There have been significant improvements in safety since the TMI accident, including the adoption of the "single failure criterion" which states that no single failure of any component, system, operator action or maintenance error shall result in any condition other than a safe state. We also have witnessed the role of a ***good*** operator who safely ditched his aircraft on the Hudson River in New York, saving all passengers and crew who were on board. We understand the value of a well-trained and experienced operator, whether in aviation or nuclear. Safety culture, ever evolving and improving, recognizes the importance to safety of all human activities along the chain from the design office to electricity generation. We understand the consequences when an institution does not embrace a safety culture and when human performance does not meet expectation. This is why the World Association of Nuclear Operators (WANO) promulgates safety culture as first and foremost in any nuclear organization – we are, in fact, hostages of each other because any one of us can take us all down!

[Photo source: World Nuclear Association Picture Gallery. Image: Areva]

Embalse Refurbishment – Aging, Safety Assessment, And The Path Forward

Ricardo Sainz[1], Damian Fornero[1], Gustavo Diaz[1], Ralf Gold[2], Rick Dam[2], Laurie McCrea[2]

[Ed. Note: The following paper was presented at the 8th International Conference on CANDU Maintenance in Toronto, Ontario, Canada on November 16-18, 2008.]

Abstract

The Embalse Nuclear Power Station has been engaged in Pre-refurbishment activities for two years. The primary focus has been on the first phase Pre-Project Condition Assessment Program (PCAP). This phase of the Refurbishment and Life Extension (RLE) project consists of all preparatory activities that are required to define the refurbishment scope and costs, and for input into the utility business case for the RLE project.

As part of an overall Plant Life Management (PLiM) program, the following activities have been performed:

1. Systematic and rigorous condition assessments / life assessments (including Health Prognosis and Recommendations)
2. Assessment of design and safety analysis features at Embalse, relative to current technology and licensing practices
3. Pre-Project activities related to: Retube, Steam Generator replacement, and Digital Control Computer (DCC) replacement

The program has been a joint effort of Embalse NPS-NASA, AECL, ANSALDO and several other support organizations. Details of the planned program were addressed previously in a paper presented at the 28th CNS Conference (2007), entitled "Embalse Refurbishment – Pre-Project Condition Assessment Phase 1". Since that time, significant progress has been made towards completing the assessment program and planning for the next steps.

This paper presents the progress of Refurbishment and Life Extension (RLE) Program at Embalse Nuclear Power Station with specific emphasis on the PCAP efforts. This includes a discussion of the benefits and lessons learned from RLE project's perspective, and an overview of some key conclusions of the aging assessments. Finally, this paper outlines the path forward.

It should be noted that results of assessments presented in this paper are very conservative. This is driven largely by the fact that there are currently uncertainties in equipment condition that can be addressed through the activities recommended as an outcome of these assessments.

1. Introduction

The Embalse Nuclear Power Station (NPS) has been engaged in Pre-refurbishment activities for two years. The primary focus has been on the first phase Pre-Project Condition Assessment Program (PCAP) that consists of all preparatory activities required to define the refurbishment scope and costs, and for input into the utility business case for the Refurbishment and Life Extension (RLE) project.

As part of an overall Plant Life Management (PLiM) program, the following activities have been performed:

1. Systematic and rigorous condition assessments / life assessments (including Health Prognosis and Recommendations)
2. Assessment of design and safety analysis features at Embalse, relative to current technology and licensing practices
3. Pre-Project Activities Related to: Retube, Steam Generator Replacement, and Digital Control Computer (DCC) replacement

Each of the above will be briefly discussed within this paper. The methodology applied in conducting this type of work was the topic of a previous paper Ref. [1].

1.1 General Considerations About Embalse NPS

The Embalse NPS is located on the shores of the Embalse lake in the Córdoba province, Argentina and is operated by Nucleoélectrica Argentina Sociedad Anónima (NASA) who also operate Atucha I (C.N.A.I, a PHWVR designed by SIEMENS-KWU).

Embalse NPS is a CANDU®[3]6 type reactor with 648 MWe output. The plant achieved first criticality in March 1983 and commercial operation began in January 1984. In the last 10 years it has shown an excellent performance with an average 88.25 % Capacity Factor (CF). Since 1992, planned outage programs at 18-month operation intervals have been implemented.

Embalse NPS was designed (as with other early CANDU¨ 6 reactors) with a 30-year design life at an average CF of 80%. Due to its very good performance in the last ten years at CFs well over 80%, the plant design life will be reached before the 30-year design life, and it is now estimated to be in 2011.

An extended outage tentatively scheduled to begin in the year 2011 (known as the 'Refurbishment Outage') provides a unique opportunity for replacement and/or refurbishment activities recommended to extend the life of the reactor (by an additional 30 years beyond the end of Design Life).

1 NASA Nucleoelectrica, Embalse NPS, Argentina
2 Atomic Energy of Canada Limited, Mississauga, Ontario, Canada
3 "CANDU" is a registered trade-mark of Atomic Energy of Canada Limited

2. Condition Assessment (CA) / Life Assessment (LA)

CA and LA are two techniques being used to assess aging degradation of the Embalse plant, and to assess the health/life prognosis of equipment for service life extension. The aging assessment portion of the PCAP is comprised of 118 CA or LA studies in total for which the responsibility is shared among NASA, AECL and other organizations as follows (refer also to Figure 1):

- CAs and LAs performed by NASA with final review by AECL
- CAs and LAs performed by NASA with AECL's assistance
- CAs and LAs performed by AECL with final review by NASA
- CAs and LAs performed by NASA and others (e.g. ANSALDO for turbine generator and Balance Of Plant). On these studies, NASA is cooperating with suppliers and other consultants.

AECL's scope of work is focused mainly on system studies, and major nuclear equipment such as nuclear piping, nuclear vessels, the reactor structure, etc. NASA is completing the balance of work with support on specific studies from AECL or other consultants.

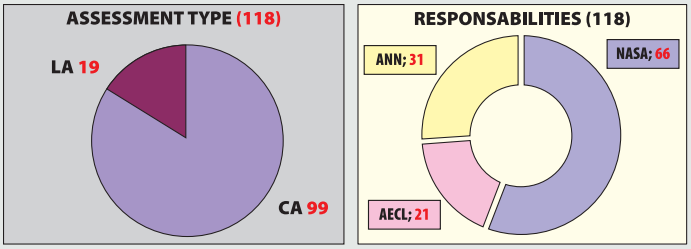


Figure 1 Distribution of Responsibility for Aging Assessment

2.1 Some Key Aging Assessment Results

At the time when the previous paper was presented, most of the assessments were started, but few were completed. Now as the project nears completion, aging assessment results of many of the significant plant Systems, Components, and Commodities (SCCs) can be discussed; some are briefly described below.

It should be noted that results of assessments presented in this paper are very conservative. This is driven largely by the fact that there are currently uncertainties in equipment condition that can be addressed through the additional activities recommended as an outcome of these assessments. Using such a conservative approach implies that once recommendations are implemented to address the uncertainties, component condition will not be worse than was predicted.

Civil Structures (Reactor Building, Internal Structures, Liner) – Civil structures will continue to meet their intended functional requirements for reliable operation with implementation of the following recommendations:

- Replace joint sealant (Thiokol)
- Develop and implement an Aging Management Program (AMP) for civil structures
- Incorporate enhancements/improvements to specific procedures (e.g. concrete repair)
- Partially reline Dousing Tank

Figure 2 which depicts signs of degradation observed at joints and in the Dousing tank, lends support to the above noted recommendations.

Joint Deterioration Bubble in Tank Liner

Figure 2 Observations of Degradation Related to Civil Structures

Nuclear Piping (Primary Heat Transport, Moderator, Other Systems) – For assessment the nuclear piping systems were divided into three:

1. Primary Heat Transport (PHT) and Auxiliary Systems
2. Moderator and Auxiliary Systems
3. Other Systems – Emergency Core Cooling (ECC), Dousing, Emergency Water Supply (EWS), Liquid Injection Shutdown System (LISS) and Liquid Zone Control (LZC)

Overall the nuclear piping and supports will continue to meet their intended functional requirements for continued reliable operation with implementation of the following recommendations:

- Execute recommendations made during field walk downs conducted in December 2005 and April 2007. Refer to Figure 3.
- Include small-bore piping in station inspection programs.
- Inspect sections of buried piping.
- Include pipe supports in piping inspection programs.
- Implement improvements to existing maintenance programs for consistency with what other stations are doing.

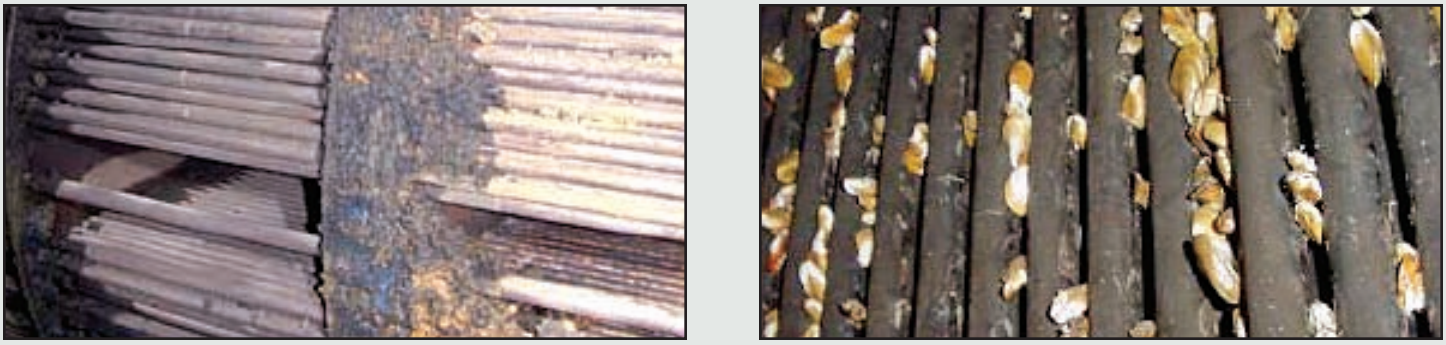
Large Nuclear Vessels - Nuclear vessels including the pressurizer, degasser condenser, ECC gas tank, ECC water tanks, and various ion exchange columns and their associated supports will continue to meet their intended functional requirements for reliable operation with the implementation of recommendations to address the following: laminations detected in the ECC gas tank (assessed as manufacturing defect that has not progressed), a high Cumulative Usage Factor (CUF) in the degasser condenser supports, and the potential for fatigue of pressurizer spray nozzles and thermal sleeve.

Large Nuclear Heat Exchangers – Included Shutdown Coolers, PHT Purification Interchangers, PHT Purification Cooler, Main Moderator Heat Exchangers, and the ECC Heat Exchanger. Each of these heat exchangers will continue to

Figure 3 Pictures Showing Condition of Select Nuclear Pipelines

Supports Not Taking Loads

Other Signs of Degradation



Deposits on Tube Bundle

Mussels in Tube Bundle

Figure 4 Deposits In Heat Exchangers Cooled with Lake Water

meet it's intended functional requirements for reliable operation with the implementation of recommendations to address the following: Flow Induced Vibration (FIV) of tubes, thinning of heat exchanger shells, and the effects of Microbially Influenced Corrosion (MIC) due to cooling with raw service water (refer to Figure 4).

Enhancements to the existing preventive maintenance and chemistry programs are generally recommended to managethese aging mechanisms.

Feeders -The feeders are planned to be replaced as part of refurbishment activities. Refer to Section 4.1 for more details.

Steam Generators - The steam generators are planned to be replaced as part of refurbishment activities . Refer to Section 4.2 for more details.

Digital Control Computers – Replacement of the computers is planned to address current obsolescence issues. Refer to Section 4.3 for more details.

I&C Commodities – Transmitters, Relays, Solenoid Operated Valves (SOVs), Panels, Power Supplies, Resistance Temperature Detectors (RTDs), Junction Boxes, etc., were evaluated as commodity groups. The primary issues addressed via these assessments include: the potential for common mode failure when the same models are employed in large numbers throughout the station, the availability of spares, and obsolescence.

Process Systems – Systematic screening was employed in system CAs in order to identify components that require further aging evaluation with the project. One of the primary goals was to establish the scope of related commodity CAs where many of the components requiring further evaluation would be assessed. Those components not covered by commodity CAs were dispositioned as not requiring further evaluation or were evaluated within the system CA.

2.2 Factors Influencing Aging Assessment Results

Some of the factors influencing aging assessment results are:

- Raw service water system used for cooling – unlike other

stations which employ a closed circuit demineralised cooling water circuit
- Existing maintenance programs could benefit from improvements, e.g. the addition of new activities, tailoring existing activities to deal with aging, optimization of frequencies, etc.
- Uncertainty in equipment condition – in many cases the current condition is unknown and inspections may be needed to confirm current condition. All of the above, and in particular the last bullet, contribute to a more conservative evaluation. Often such a conservative approach results in a less than good health prognosis[2] being assigned, which may be augmented to good if recommended actions are taken to reduce uncertainties.

3. Safety Assessment

The main objective of the safety assessment portion of the PCAP is to assess the design and safety analysis features at Embalse NPS, relative to current technology and licensing practices. AECL has been assisting NASA in this activity through the preparation of various documents on the topics of CANDU¨ 6 safety design related changes, review of Embalse plant trip parameters, input for the licensing basis, and others, through technical support.

3.1 Main Elements of Embalse Safety Assessment Program

Overall the Safety Assessment Program for Embalse NPS covers a wide range of activities, the most relevant being:

A) Consolidation of Level 1 Probabilistic Safety Assessment (PSA) (e.g. for the review of system reliability, which is based on PSA models).
B) Definition and execution of new Deterministic Studies
C) General up-dating of Embalse«s Safety Report
D) Analysis of plant compliance with Canadian Nuclear Safety Commission (CNSC) Standards
E) Analysis of plant compliance with Autoridad Regulatoria Nuclear (ARN) Standards
F) Analysis of Reactor Trip Coverage
G) Review of Site Seismic Conditions
H) Seismic Margin Assessment
I) Provision and review of a Generic Level 2 PSA
J) Severe Accident simulations and analyses
K) Severe Accident Management
L) Simplified verification of plant compliance with general AR 3.1.3 Standard
M) Licensing Basis Document (LBD)
N) Planning of Periodic Safety Review (PSR)

3.1.2 Tasks Completed

- Item "A" above - fully completed with the present issue of Fire PSA Final Report, together with the consolidation of the Final CDF value.
- Item "D" above - verification of compliance with CNSC Standards R-7, R-8, R-9, R-10 and R-77.
- Item "E" above - verification of compliance with ARN Standard 3.4.2
- Items "M" and "N" above – preliminary drafts completed

3.1.3 On-Going Tasks

- Elaboration of Embalse«s Safety Analysis Plan, as a technical specification to AECL for the execution of Item "B" Deterministic Studies
- Initiating survey of all ARN Standards required to be in-compliance
- Analysis of Events Catalogues for Reactor Trip Coverage, based on Embalse PSA, CNSC R8/10 Standards and AECL«s proposal.
- Elaboration of reviewed versions of LBD and PSR Program documents
- Item "G" above - under discussion with AECL and the University of Cordoba

3.1.4 Planned Activities in the Short-Term

- Discussions with AECL leading to a contract for the execution of New Deterministic Studies
- Discussions with AECL leading to a draft scope of supply for other major safety assessment activities

4. Retube, Steam Generator Replacement, and DCC Replacement

A significant outcome of the Embalse PCAP is that retubing, steam generator replacement, and DCC replacement are planned to extend the life of the plant. Each of these activities is briefly described in the subsections that follow.

4.1 Retubing

Retubing involves the large-scale replacement of all fuel channels, calandria tubes and feeder piping components. This entails replacement of portions of the pressure boundary of the primary heat transport system and the calandria vessel, which is part of the moderator system. Other systems affected by retubing are the annulus gas system and those instrumentation systems in which tubing in the upper feeder cabinet is removed to provide access for upper feeder replacement. The work associated with retubing is complex and will be executed by a diverse workforce made up of AECL, NASA and contractor staff.

Following planning, training, and other pre-outage activities, retubing will generally be comprised of the following key steps:

2 The Condition Assessment methodology provides for very specific Health Prognosis definitions, which takes into account a number of factors including uncertainties.

1. Placing the reactor into guaranteed shutdown state. After shutdown reactor systems must be laid up in a state that allows replacement of the required components, e.g. the primary heat transport system must be de-fuelled and then the heavy water drained and stored for the duration of the retube outage, installation of reactivity mechanism deck cover, etc.
2. Preparation activities such as removing obstructions from the work areas within the reactor building, preparing the fuelling machine bridge for retubing, installing and commissioning support equipment in the reactor building work areas, removing reactor face insulation and portions of the feeder cabinet.
3. Removal of feeder components, fuel channels and calandria tubes. All feeders, end fittings (end fitting body, liner tube, shield plug, closure seal insert, outboard bearing sleeve and inboard journal ring), channel closures, calandria tubes, pressure tubes and positioning assemblies will be replaced with new components.
4. New feeder installation commences with the installation of upper feeder piping, followed by the installation of calandria tubes and fuel channels.
5. New fuel is loaded into the reactor and new channel closures and shield plugs are installed.
6. Finally close out support activities are done, i.e. removing temporary retubing support equipment, etc.

A Qualification Program for the local supply of reactor components is in place. This has two phases:

- Phase 1 – an initial assessment of the supplier's capability; and
- Phase 2 – an in-depth qualification program after which the successful supplier would be qualified to provide replacement reactor components for CANDU¨ reactors and be eligible to bid for the Embalse retubing program and the new build project. Phase 2 includes the qualification of Comision Nacional Energia Atomica (CNEA) laboratories in Argentina.

Phase 1 has already been finished and NASA with AECL's assistance is currently involved in Phase 2. CONUAR has been identified as the supplier of reactor components with CNEA as an independent agency performing sample qualification tests.

4.2 Steam Generator Replacement

NASA and AECL has commenced engineering activities related to the replacement of the Embalse steam generators in order to support continued operation of the Embalse NPS for an extended period.

Two options for the steam generator replacement were evaluated:

1. Steam Generator Cartridge (SG portion below the drum) replacement
2. In situ retubing (Significant degradation of the tube support plate has been identified, which cannot be replaced without removal of the tube bundle)

The evaluation conducted showed that the in situ option has higher risk and there are no industry precedents for in situ retubing of steam generators in an operating plant. Hence the steam generator cartridge replacement option was selected.

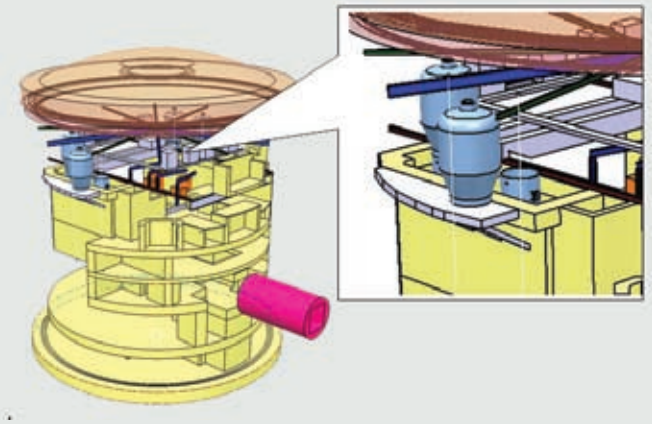


Figure 5 Steam Drum Removal

Figure 5 shows how the steam drum will be cut and moved aside in order to remove the cartridge.

A project implementation plan has been outlined identifying NASA as the project manager with AECL and IMPSA (a local manufacturer) in cooperation with B&W Canada on design transfer and technical / procurement support. The impact on the Reactor Retube schedule was assessed. The potential extent of local supply of materials and services has also been factored into the plan. Two local companies IMPSA (SG main supplier) and FAE / CONNUAR (potential SG tubing supplier) have been evaluated and accepted (with conditions) by AECL.

For the steam generator cartridge replacement Qinshan SG design has been assumed as the reference design. Since the replacement tube bundle is larger than the old Embalse SG tube bundle, a system analysis is being conducted to upgrade the overall station performance. The biggest challenge to meet the cartridge delivery for 2011 Retube Outage is coming from sourcing long lead items like the tubesheet forging and the tubing due to high world wide demands for the same items or their constituent materials.

A preliminary installation study was performed and indicated that the SG Cartridge replacement option is feasible and can be implemented using the Equipment Airlock. Temporary material handling equipment, structural steel for temporary structures and shoring of some floors would be required for the transporting the cartridges out of and into the Reactor Building. Although some challenges are expected since this would be a First of A Kind procedure for a CANDU¨ 6 plant, sufficient industry experience exists to draw upon to reduce the risk of the implementation.

The replacement plan includes the re-use of all the SG supports (except for the backup) with minor modification to the lower lateral support. Also the steam drum will be re-used, and as such, is undergoing inspection and an assessment of the remaining life.

4.3 Digital Control Computer Replacement

The DCCs are obsolete and are planned to be replaced for life extension. Two alternatives for replacement were assessed by CANDU Owners Group (COG) Joint Project Phase 1:

1. Change to a Distributed Control System
2. Replace the existing Varian V-70 with a SSCI-890 emulator

The second alternative was selected. This is a similar system to that currently used by AECL in newer CANDU¨ stations. The same system has also been selected by other CANDU¨ utilities such as Wolsong in Korea and Gentilly II in Canada.

The following activities were conducted (May 2007):

- Acquire Intellectual Property rights from SSCI
- Design solutions for obsolescence issues
- Manufacture of prototype DCCZ
- Acceptance of prototype
- Training
- Long Term Support
- Find a suitable company to perform the above

Policies of the DCC replacement are:

- To maximize NASA's participation in the development and implementation of the project (to build NASA's experience in this area)
- To use AECL as the main contractor responsible for the project management for all phases of the project.

Contractual details are under discussion with AECL for the supply of the required hardware and software. The assembly and commissioning of the new DCCs will be under NASA responsibility.

5. Other Areas of Interest for Plant Life Extension (PLEx)

Related to extending plant life, there are also a number of other activities that are already in place or are planned to be implemented in the near future.

Two major programs are:

1. Obsolescence Program
2. EQ Program

Other modifications and corrective actions include:

- Retubing the Main condenser
- Painting the inner surfaces of the Condenser Cooling Water piping
- Implementing improvements to the In Service Inspection (ISI) Program
- Changing the last stage Low Pressure Turbines blades
- Installing a new inverter Class II for BUC installation
- Refurbishment of the Reactor Building and Turbine Building cranes
- Replacement of transformers containing PolyChlorinated Biphenyls (PCBs)
- Replacement of Turbine electro hydraulic controls
- Replacement of all equipment related to Chilled Water Supply to the Local Air Coolers (LACs) of the RB.
- Replacement of the Service Water rotating filters
- Piping and supports inspections
- Circuit Breaker replacement (2GG)
- Installation of a Recirculating Cooling Water (RCW) system
- Replacement of many obsolete I&C components
- Up-rating related modification on Nuclear Steam Plant (NSP) and Balance of Plant (BOP)
- Modifying electrical equipment due to new configuration and equipment
- Performing seismic related modifications
- Informing the public about the project

6. Conclusions

The Embalse NPS has been engaged in Pre-refurbishment activities for two years. As the project nears completion, results are available which provide input to the business case, help to define the scope of the refurbishment outage, help to identify improvements or enhancements to existing plant maintenance and inspection programs, and can be used to develop an ongoing Aging Management Program.

For life extension three major pieces of equipment will be replaced during the refurbishment outage. These are the feeders, steam generators, and DCCs. Other major systems and components should be able to continue to operate to the end of design life, but may require that mitigating actions be taken to extend their life further, e.g. repairs to civil structures, heat exchangers, and select nuclear pipelines, or that improvements be made to the existing maintenance programs. To further support extending the life of the plant an Obsolescence Program, an EQ Program and other modifications or corrective actions are already in place or planned to be implemented in the near future.

Beyond pre-refurbishment activities, engineering, procurement and other preparatory activities are needed to proceed with reactor refurbishment. Implementation will follow including all field activities carried out during the outage. The work associated with refurbishment is complex and a diverse workforce will be needed to plan, prepare and execute reactor refurbishment activities needed to extend the life of the Embalse NPS for an additional 30 years beyond the end of it's current design life of 2011.

7. Acronyms

AECL	Atomic Energy of Canada Limited
AMP	Aging Management Program
ARN	Autoridad Regulatoria Nuclear
B&W	Babcock and Wilcox
BOP	Balance of Plant
CA	Condition Assessment
CANDU¨	CANada Deuterium Uranium, registered trademark of AECL
CF	Capacity Factor
CNEA	Comision Nacional Energia Atomica
CNSC	Canadian Nuclear Safety Commission
CNS	Canadian Nuclear Society
COG	CANDU Owners Group

CUF	Cumulative Usage Factor
DCC	Digital Control Computer
ECC	Emergency Core Cooling
EQ_	Environmental Qualification
EWS	Emergency Water Supply
FIV	Flow Induced Vibration
I&C	Instrumentation and Controls
ISI	In Service Inspection
LA	Life Assessment
LAC	Local Air Cooler
LBD	Licensing Basis Document
LISS	Liquid Injection Shutdown System
LZC	Liquid Zone Control
MHTS	Main Heat Transport System
MIC	Microbially Influenced Corrosion
MW	Mega Watt
NASA	Nucleoeléctrica Argentina Sociedad Anónima
NPS	Nuclear Power Station
NSP	Nuclear Steam Plant
P&IC	Pressure and Inventory Control
PCAP	Pre-Project Condition Assessment Program
PCB	PolyChlorinated Biphenyls
PSA	Probabilistic Safety Assessment
PSR	Periodic Safety Review
PHT	Primary Heat Transport
PLEx	Plant Life Extension
PLiM	Plant Life Management
RB	Reactor Building
RCW	Recirculating Cooling Water
RLE	Refurbishment and Life Extension
RTD	Resistance Temperature Detector
SCC	Systems, Components, and Commodities
SG	Steam Generator
SOV	Solenoid Operated Valve

8. References

[1] G. Diaz, R. Sainz, R. Gold, R. Dam, J. Nickerson, "Embalse Refurbishment – Pre-Project Condition Assessment", presented at 28th CNS Annual Conference & 31st Annual CNS/CNA Student Conference, Saint John, New Brunswick, 2007 June.

A Last Look At PLGS Life-Limiting Feeder Degradation

J.P. Slade[1], T.S. Gendron[2]

[Ed. Note: The following paper was presented at the 8th International Conference on CANDU Maintenance in Toronto, Ontario, Canada on November 16-18, 2008.]

Abstract

Severe feeder degradation was one of the main drivers for PLGS refurbishment three years prior to its design life. The first part of this paper provides an overview of PLGS feeder degradation, including wall thinning adjacent to the Grayloc hub weld.

PLGS shut down for refurbishment in March 2008 after ~21 FPY service. The entire feeder assembly is being replaced with improved piping that is expected to achieve its 24 FPY post-refurbishment design-life. The second part of this paper provides a summary of these improvements.

The paper concludes with a discussion of plans to manage feeder degradation during post-refurbishment operation with the goal of ensuring the feeders achieve their design intent with minimal maintenance.

1. Introduction

PLGS has experienced some of the most severe feeder degradation within the CANDU industry. It is the only CANDU reactor to replace feeder bends because of cracking. The projected need to replace feeders because of life limiting cracking and wall thinning was one of the main drivers for PLGS refurbishment three years prior to its design life. The first part of this paper provides a high level summary of PLGS feeder degradation and its management for the first ~21 FPY of operation.

PLGS shut down for refurbishment in March 2008. All feeders are being replaced from the fuel channel connections up to the header nozzles. The second part of this paper provides a summary of the design improvements that are expected to prevent feeder life-limiting degradation for PLGS's 24 FPY post-refurbishment design-life. The paper concludes with a discussion of changes to PLGS feeder management strategies and activities for post-refurbishment operation.

2. PLGS Feeder Degradation Operating Experience

This section provides a high-level summary of PLGS feeder degradation and management strategies during pre-refurbishment operation. Wall thinning adjacent to the Grayloc hub weld is described in more detail; more information on the other topics can be obtained from previous publications [1-4]. For COG members, there are numerous Feeder Integrity Joint Project

1 NB Power Nuclear, Lepreau, New Brunswick, Canada
2 Atomic Energy of Canada Limited, Chalk River, Ontario, Canada

Table 1: PLGS Feeder Replacement History Prior to Refurbishment Tight Radius Outlet Feeder Bends

Feeder	Bend with* crack	Surface with Crack	Max Crack Size (mm)		Detected / Removed		Crack Detected by	Previous Inspection	
			Long	Deep	Year	FPY		Date	FPY
Feeders Removed with Confirmed Cracks – all 2.5" Diameter Pipe									
S08a	1st	Inside	63	7.0	1997	12.5	Leak	-	-
K16a	1st	Inside	55	7.3	2001	15.4	Leak	-	-
U15c	1st	Inside	30	5.7	2001	15.4	UT	-	-
Q08a	1st	Inside	50	3.6	2001	15.4	UT	-	-
N19a	2nd	Inside Outside	66 40	6.9 4.8	2003	17.4	UT	-	-
C13a	1st	Inside	38	5.8	2003	17.4	UT	May 2001	2.00
P09a	1st	Inside	15	3.7	2003	17.4	UT	May 2002	1.11
N11a	1st	Inside	18	2.8	2004	17.9	UT	Sept 2003	0.58
D14a	2nd	Outside Inside	15 19	2.7 2.5	2005	18.6	UT/ET Burst Test	May 2004	0.73
H12a	2nd	Outside	17	3.2	2006	19.5	UT	Apr 2005	0.87
N16c	1st	Inside	28	3.3	2006	19.5	UT	Apr 2005	0.87
N12c	1st	Inside	~25♠	2.9♠	2007	20.2	UT	Apr 2006	0.73
Feeders Removed due to False Positive NDE Indications – all 2.5" Diameter Pipe									
E08c	2nd	Inside	-	-	2005	18.6	UT	May 2004	0.73
E14c	2nd	Inside	-	-	2005	18.6	UT	May 2004	0.73
K05c	1st	Inside	-	-	2005	18.6	UT	May 2004	0.73
P18c	2nd	Inside	-	-	2005	18.6	UT	May 2004	0.73
L16c	1st	Outside	-	-	2005	18.6	ET	May 2004	0.73
O07c	1st	Outside	-	-	2005	18.6	UT	May 2004	0.73
Feeders Removed due to Wall Thinning – all 2" Diameter Pipe									
Feeder	**Minimum Wall Thickness**		**Removed**		**Measured By**		**Previous Inspection**		
	Bend with* Minimum	**Measured in 2005 (mm)**	**Year**	**FPY**			**Date**	**FPY**	
C06	2nd	2.96	2005	18.6	METAR		May 2004	0.73	
C17	2nd	2.99	2005	18.6	METAR		May 2004	0.73	
D05	2nd	2.85	2005	18.6	METAR		May 2004	0.73	
D18	2nd	2.85	2005	18.6	METAR		May 2004	0.73	
E19	1st	3.17	2005	18.6	METAR		May 2004	0.73	
H02	1st	3.02	2005	18.6	METAR		May 2004	0.73	

UT – Ultrasonic Crack Detection Inspection ET – Eddy Current Inspection ♠ estimated from NDE
* if unacceptable degradation was detected in a compound bend, both bends were replaced

reports that provide a wealth of additional information about work that contributed to this summary.

NBPN replaced tight radius outlet bends from twenty-four feeders during the first ~21 FPY of PLGS operation. Twelve were replaced because of cracking at bends, six because of wall thinning at bends, and six because of false positive inspection indications of cracking. Information about these feeders is summarized in Table 1.

2.1 Feeder Wall Thinning

Excessive wall thinning at feeder bends near the reactor outlet was first discovered by inspections at PLGS in 1995. Since that time, comprehensive inspections, examinations of removed feeders, and research programs have identified the rates and patterns of wall thinning throughout the feeder system, and the mechanism and key fac-

tors driving it. For operation up to reactor refurbishment, the primary strategy to manage feeder wall thinning has been inspection and repair, requiring replacement of bends from six 2" diameter feeders. The subsections below provide an overview of these topics.

Mechanism

The mechanism of wall thinning was identified as Flow Accelerated Corrosion (FAC) based on the thin magnetite film (~1-4 microns) and scalloped appearance of feeder inside surfaces (Figure 1), and the constant corrosion rates. FAC is caused by coolant flow and chemistry conditions that remove the magnetite film that normally protects the feeders from corrosion, and promote a high transport rate of corrosion reactants and products to and from the surface, respectively.

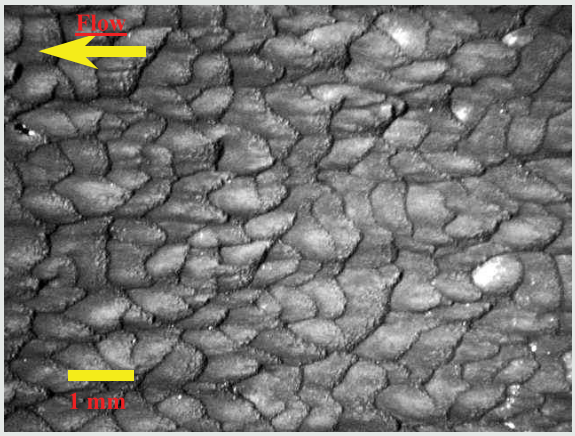


Figure 1: Scallops on Feeder S08a

Key Factors Causing Feeder Wall Thinning

The primary factors causing feeder wall thinning are given in Table 2. All original PLGS feeder material has relatively low chromium content (~0.02wt%) and is susceptible to FAC when key environmental factors are present. These factors are cool-

Table 2: Key Factors Causing Feeder Wall Thinning

	Key Factor	Affects Location
Material	Geometries that create turbulence[1]	Downstream of fuel channel outlets, bends, orifices, reducers
	Areas thinned during fabrication	Bend extradoses, grinding spots at welds
	Steel with low wt% Cr	All feeders (~0.02wt%Cr)
Environment	High coolant velocity / turbulence	High power channel feeders more affected
	Coolant unsaturated in iron (high temperature, low dissolved iron)	Outlet feeders only
	Coolant pHa	FAC minimized at 10.2-10.4

Figure 2: Spare Bend Apex

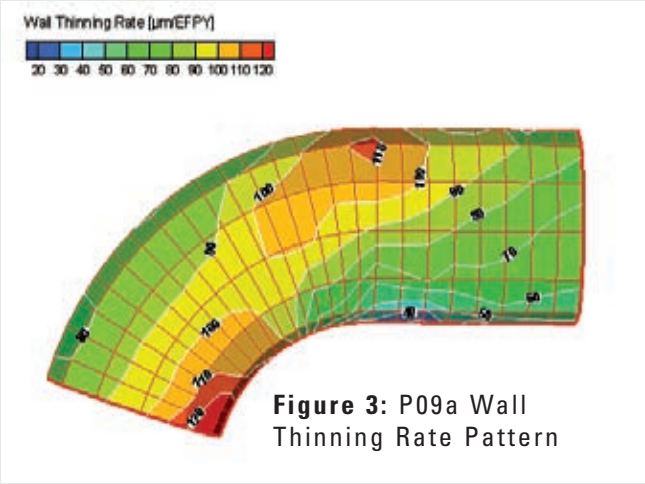


Figure 3: P09a Wall Thinning Rate Pattern

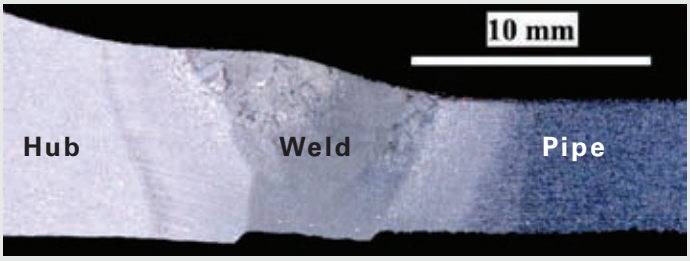
ant that is both turbulent1 and is unsaturated in dissolved iron with respect to the formation of magnetite. Turbulence occurs to varying degrees throughout the feeder system, dependant on coolant velocity and geometries that promote local flow disturbances. However, the coolant is only unsaturated in iron in outlet feeders and hot-leg piping where the temperature is high and dissolved iron has already precipitated in the cold-leg of the circuit, in particular in the steam generators and inlet feeders and headers. Based on field experience and research results [5], utilities also aim to operate at the low end of the coolant pHa specification (10.2-10.4) to minimize FAC rate. PLGS has been doing so since 1996.

Another important factor that affects the lifetime of piping affected by FAC is the initial pipe wall thickness. Locations where the initial thickness is relatively low from fabrication steps such as bending and grinding are more susceptible to life-limiting wall thinning. The "warm bending" procedure [6] used to bend PLGS feeders thickens the bend intrados and thins the extrados, as shown in Figure 2.

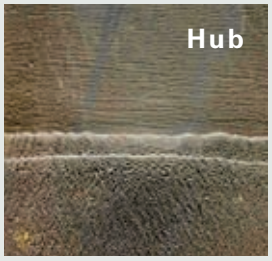
Rates and Patterns of Wall Thinning

The variation in key factors present in the outlet feeders gives rise to varying wall thinning rates and patterns. Maximum rates of individual feeders estimated by repeat wall thickness measurements made beginning after ~12 FPY range from ~0.03 up to

1 More specifically, high mass transfer rates in the coolant boundary layer at the pipe wall



a) Cross section of S08a after ~13 FPY



b) Plan view, O07a after ~18 FPY

Figure 4: Step profile of the Grayloc hub-feeder weld location

deep as 0.4mm. When these features were mechanically removed, the ultrasonic indications also disappeared. A review of past inspection reports suggests that these axial patterns became more distinctive with time and created ultrasonic indications that only became rejectable after ~18 FPY. Use of a modified COG crack inspection procedure since 2005 has been successful in distinguishing indications between scallop patterns and cracks. There have been no additional false positive indications.

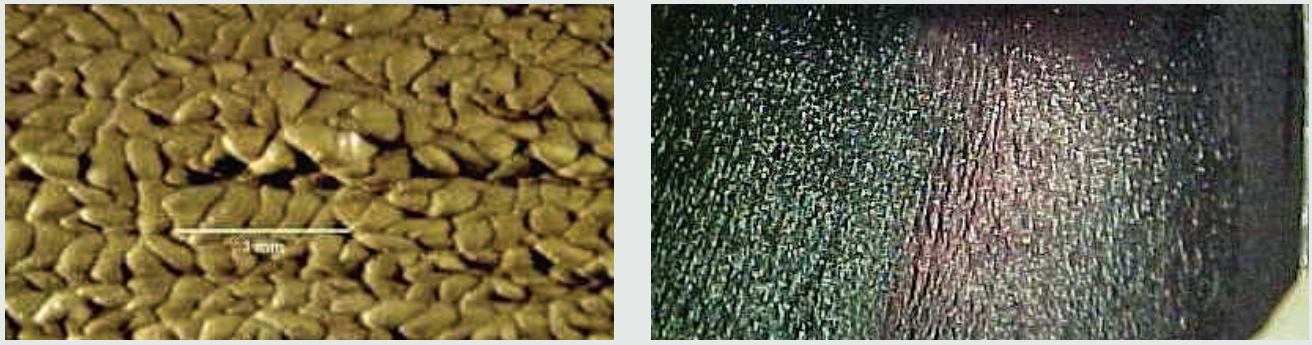


Figure 5: Axially aligned scallop patterns created after ~18FPY in feeder E14c

~0.13mm/FPY for the highest velocity channels. The highest rates are at the intrados upstream of the first two tight radius bends and at the bend extradoses near the bend apex. The pattern from a PLGS removed single bend is shown in Figure 3.

Wall thinning has occurred over the whole length of outlet feeders but at lower and variable rates (resulting from geometric factors) downstream of the first bends. For example, in the highest velocity channels, wall thinning rates of bends in the upper feeders are ~15% lower than the first bends. Although no upper feeder locations were life-limited to 2008, ~75-100 90° bends downstream of the field weld were predicted not to achieve the post-refurbishment design life.

At the outlet Grayloc connection, the variation in chromium content between the hub (~0.12wt%), the pipe (~0.02wt%), and the weld between (~0.07%), led to different FAC rates, and the creation of a surface step profile in the axial direction. Figures 4a and b illustrate this in cross-section and plan-view. This profile has been observed on all removed PLGS feeders and is most pronounced at the intrados, where FAC rates are higher. The preferential wall thinning of welds reported by EPRI [7] has never been observed on PLGS feeders. However, thinned areas adjacent to the Grayloc welds with subtle profiles have developed. The dark patch in the center of Figure 5b (beneath the weld) is the most acute thinned area of this type observed at PLGS. This is discussed in more detail in the subsection below.

The development of surface scalloping is worth further mentioning because some of the false positive crack indications in 2005 were attributed to scallop patterns. All four feeders that were repaired because of false positive indications of inside surface cracks (Table 1) were examined in the locations of the rejectable indications. In each case, axially aligned scallops, which had created groove-like features, were observed (Figure 5) with some individual scallops as

Thinned Locations Adjacent to the Grayloc Hub Weld

Until 2006, the focus of feeder thickness measurements was the bend extradoses where high rates and low initial thickness are roughly coincident. However, after another utility discovered some significant wall thinning near hub-to-feeder welds, inspections and assessments of PLGS feeders began to target this location also. Examination of PLGS removed feeders found the thinnest location was adjacent to the Grayloc hub weld for eight of eleven 2.5" feeders that were still intact in this area. All thinned spots were subtle depressions; the most distinctive of these is shown in Figure 4b. None of the six 2" removed feeders had minima adjacent to the weld. Because the axial and circumferential position of the thinned areas was variable, it was suspected that a somewhat random factor contributed to the pattern. An investigation identified this factor to be excessive removal of metal near the welds by pre-service grinding.

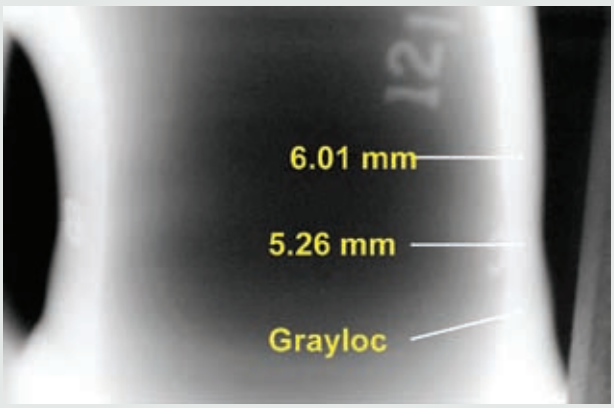


Figure 6: PLGS Feeder-HubWeld Pre-Service Radiograph

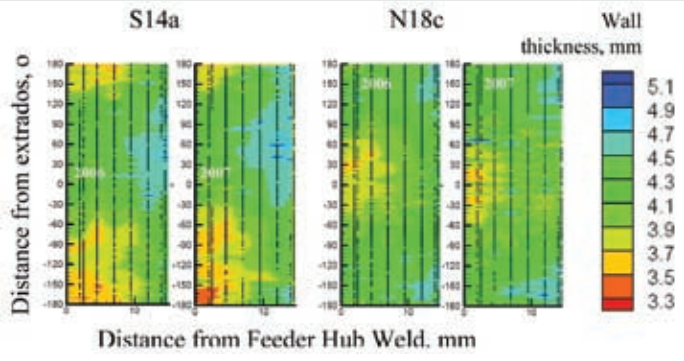


Figure 7: Wall Thinning Patterns Adjacent to the Grayloc Hub

Grinding was performed on the hub-to-pipe weld caps to aid the radiographic inspection of the weld region and also at the weld root to remove any protrusion or mismatch of the internal pipe surfaces exceeding 1/32". Pre-service radiographs and metallographic examination results have provided evidence of the degree of material removed from individual feeders. The radiograph in Figure 6 indicates the location of initial minimum wall thickness, adjacent to the weld.

This location was inspected using a COG Grayloc-Area Inspection Tool. Figure 7 shows the wall thickness pattern for two PLGS feeders over a two-year period. Feeder S14a had the least margin to the minimum allowable thickness but was not life-limiting by 2008.

Feeder Wall Thinning Management

Inspection and repair has been the primary strategy to manage feeder wall thinning. The history of outlet feeder wall thickness measurements at PLGS is shown in Table 3. By 1998, a 100% baseline measurement of outlet bends was complete. Also, 7

Year	Feeder bends		Next to Hub		Total
	2 inch	2.5 inch	2 inch	2.5 inch	
1995	4	14	0	0	18
1996	26	40	0	0	66
1997	25	157	0	0	182
1998	15	134	0	0	149
1999	11	14	0	0	25
2000	13	1	0	0	14
2002	20	5	0	0	25
2003	21	4	0	0	25
2004	21	8	0	0	29
2005	11	31	0	0	42
2006	10	14	13	67	116
2007	10	34	7	18	69
Total	**187**	**456**	**20**	**85**	**760**

Table 3: History of wall thickness inspection of PLGS outlet feeders

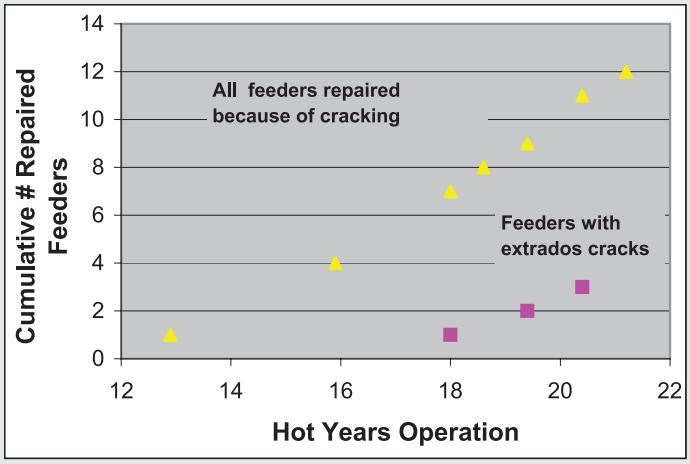


Figure 8: Rate of Feeder Repair due to Cracking

Figure 9: Feeder N19 2nd Bend. Outside surface cracks at the extrados (0°) and inside surface cracks at 115° and 247°

inlet bends and 12 inlets adjacent to the hub were inspected in 1995/96 and 2006, respectively.

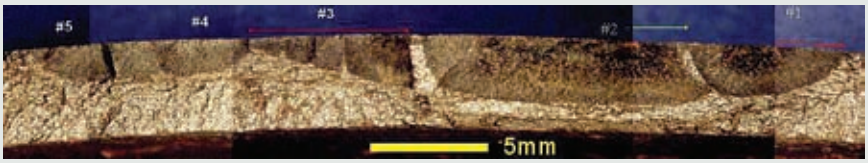
Deterministic methods were successfully used for operational assessments of bend wall thinning. The industry standard correlation between wall thinning rates and time averaged flow conditions [8] was used to identify the most limiting PLGS feeders. Wall thickness of these feeders was periodically measured to demonstrate acceptable margins and to determine when replacement was required.

An empirical probabilistic Monte Carlo model was developed to predict the minimum thickness next to the Grayloc hub because wall thinning at this location was not well characterized. The model used initial thickness data from fabrication radiographs, FAC rates based on the bend model, and considered the circumferential dependence of the FAC rate. The model was benchmarked against measurements from PLGS removed feeders.

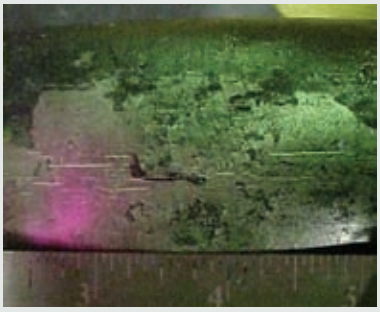
The Monte Carlo model was used to identify feeders most likely to thin below the minimum allowable thickness. It was also used to determine the minimum inspection scope required to ensure a probability <5% that one or more non-inspected feeders would fall below the minimum allowable thickness. This approach allowed the use of a risk-based inspection scope that maintained a low risk while keeping radiation exposure ALARA.

2.2 Feeder Cracking

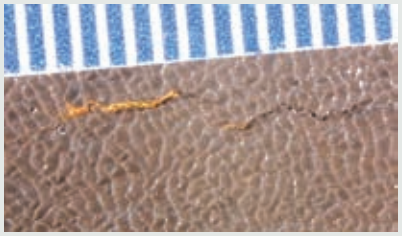
Since 1997 and after ~ 13 FPY operation, PLGS experienced life-limiting cracking in twelve feeder bends (Table 1).



Fracture surface of feeder H12a after burst testing showing outside surface cracks have started to coalesce.

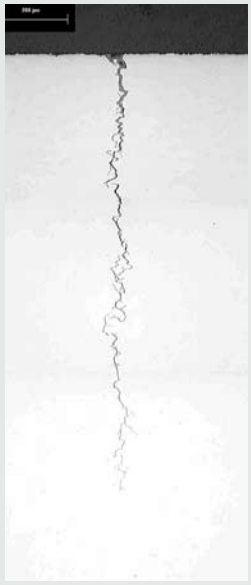


Magnetic particle image of feeder D14a bend extrados.

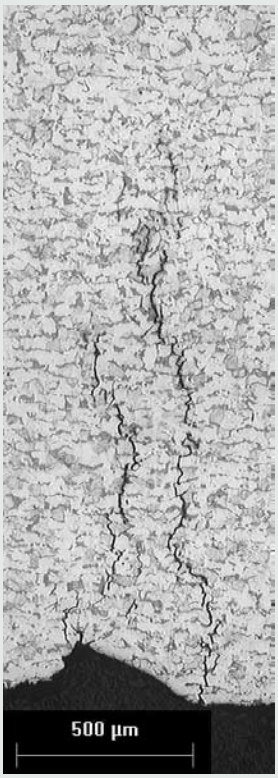


Visual image of inside surface cracks.

Optical micrograph of feeder S08a showing secondary cracking near the mouth of the main inside surface crack.



a) Outside crack



b) Inside crack

Optical micrographs of intergranular cracks in feeder N19a second bend, same scale.

Figure 10: Images of PLGS Feeder Cracks

Because this cracking is unique in the industry, has a relatively high growth rate, and has the potential for safety-related consequences if not managed properly, it has created significant challenges for NBPN. Despite those challenges, knowledge of the key factors driving cracking and a relatively linear failure rate has allowed NBPN to manage cracking economically, primarily using inspection and repair. The subsections below provide a summary of PLGS cracking up to the Refurbishment Outage.

Failure rates and Locations

Since 1997, feeder bends have been replaced because of cracking at a rate of about 1 to 2 per year. A linear fit of the data for all repaired feeders in Figure 8 shows a failure rate of 1.3 per hot year. All twelve life limiting cracks were in 2.5" diameter outlet tight radius first or second bends with an external angle of >45°. Eleven of the twelve bends had significant cracks that had initiated on the inside surface between ~30 to 75° from the intrados. Beginning in 2003, significant cracking on the outside surface of three bend extradoses was also discovered; two of those bends also had deep inside surface cracks (Table 1). Figure 9 illustrates the three locations of cracking on the second bend of feeder N19a. Examinations of removed bends have revealed that a high percentage of tight radius bend extradoses contain very shallow (50-200 microns deep) outside surface incipient cracks, that are assumed to have developed during operation. All of the observed cracking is in the location of high residual tensile stresses from the bending process [6]. In-situ ultrasonic inspection and destructive examination of removed Grayloc hubto-feeder welds did not reveal cracking on any PLGS feeder welds. No cracks were detected in 100% inlet bends inspected.

Crack Characteristics

All cracks are axial in orientation and entirely intergranular. No physical feature or surface contaminant has been observed to identify a specific mechanism of failure. Outside surface cracks tend to be straighter and have fewer secondary cracks near the main crack. Cracks initiate in multiple locations and with time, some of those that are axially aligned, coalesce to form larger cracks. Figure 10 illustrates some of these features. Additional details about the physical features and development of cracks are provided in references 1 and 4. The maximum crack dimensions from each repaired feeder are listed in Table 1.

Mechanism and Key Factors Driving Cracking

Numerous studies and comprehensive failure investigations have identified the key factors driving cracking, shown in Table 4. Although it has not been possible to conclusively determine the cracking mechanism, two likely and possibly inter-related candidates are Stress Corrosion Cracking (SCC) caused by exposure to mildly oxidizing hot coolant and Low Temperature Creep Cracking (LTCC), possibly exacerbated by atomic hydrogen flux from FAC. SCC due to air ingress or insufficient dissolved hydrogen to suppress the radiolytic generation of

Table 4: Factors Driving Feeder Cracking

Category	Primary Factors	Possible Secondary Factors
Stress	Residual Tensile Stress	Cyclic Operating Stress
Material	Cold Work	Ovality, Impurities
Environment	Temperature	FAC-hydrogen, coolant oxidizing species & impurities

oxidizing species is a credible cause of cracking initiated at the inside surface. LTCC (decohesion of grain boundaries from localization of creep strain ahead of a crack tip or another stress-concentrating feature) could explain cracks initiated at both inside and outside surfaces.

Crack Growth Rates

Crack growth rate has been estimated from OPEX (Figure 11) to be ~2mm/year in the through-wall direction. This is an average growth rate once cracks reach a detectable size. Figure 11 plots the maximum crack depth in an individual feeder versus the operating time since the last inspection when no crack was detected. Other assessments from laboratory examinations of artefacts have concluded similar rates with variation suggested with crack age (size) and slightly slower rates for cracks initiated on the outside surface.

Management

After two leaks from through-wall cracks in 1997 and 2001, NBPN realized that a different strategy was required to prevent additional leaking feeder cracks. The primary management strategy since then has been inspection and repair. This strategy was successful at detecting and repairing cracked bends before leaks developed. Table 4 illustrates the comprehensive inspection program since 1997. With on-going experience and better understanding of the key factors and the likelihood and consequences of cracking at different locations, the inspection scope evolved to become 100% inspection of all tight radius outlet first and second bends on an annual basis. This scope was supported by comprehensive probabilistic safety evaluations [3, 4] and assessments of partial-through wall crack stability from feeder burst testing [9].

3. Feeder Design Improvements Made During the Refurbishment Outage

The benefits of experience and understanding have contributed to numerous improvements to the replacement feeders being installed during the Refurbishment Outage. Neither FAC nor cracking are expected to be life-limiting during PLGS extended design life of 24 FPY. A summary of some of the key improvements is listed in Table 5. Improvements considered to have the greatest benefit are shown in bold.

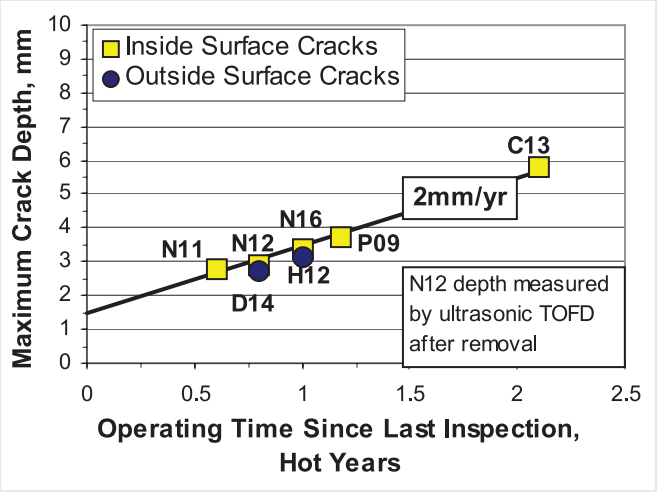


Figure 11: Average Crack Growth Rate

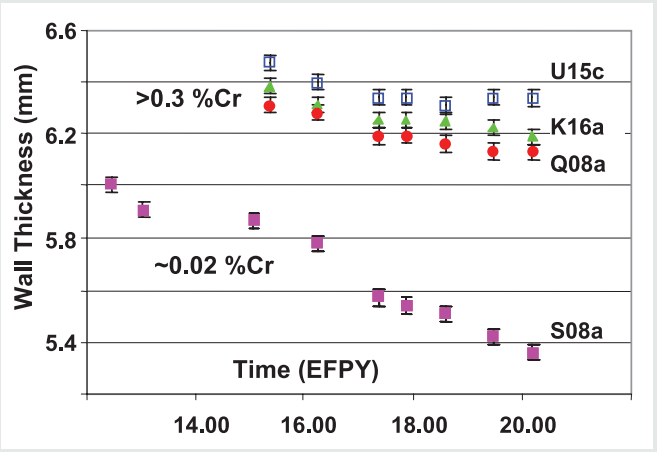


Figure 12: Wall thinning of replaced bends [10].

The use of carbon steel with >0.3wt%Cr is expected to reduce the feeder wall thinning rate by at least 50% compared to the original PLGS feeders. This is based on experimental 6.6 loop tests and wall thinning measurements of some PLGS replaced feeder bends [10]. Figure 12 compares measured minimum wall 6.2 thickness data from bend S08a which was replaced with original PLGS steel in 1997 and 5.8 three feeder bends replaced with >0.3%Cr steel in 2001. The estimated reduction in FAC rate from this data for steel with higher Cr is 5.4 ~65% [10].

4. Feeder Management Strategy after Refurbishment

The inspection and repair strategy used to manage PLGS feeder wall thinning and cracking was successful in allowing safe, reliable operation until 2008. However, feeder management during this period also had two significant drawbacks. It consumed a significant portion (~5%) of the PLGS operations and maintenance budget and it contributed to about 30% of outage dose. For post-refurbishment operation, "prevention

Table 4: Numbers and percentages of bends and welds inspected for cracking.

Date	Outlet Feeders				Inlet Feeders			Total # of Sites
	Tight Radius		Long Radius Bends	Repaired Welds	Tight Radius		Repaired Welds	
	1st Bend	2ndBend			1st Bend	2nd Bend		
1997	110 (29%)	0	0	0	48 (13%)	0	0	158
1998	14 (4%)	0	0	0	10 (3%)	0	0	24
2001	379 (100%)	41 (33%)	0	0	100 (26%)	0	0	520
2002	238 (63%)	42 (34%)	0	0	30 (8%)	0	0	310
2003	380 (100%)	178 (100%)	0	0	190 (50%)	25 (13%)	0	773
2004 (May)	347 (91%)	122 (69%)	12	21	106 (28%)	44 (23%)	23	675
2004 (Oct)	48 (13%)	6 (3%)	0	0	0	0	0	54
2005	380 (100%)	178 (100%)	9	8	58 (15%)	34 (21%)	5	672
2006	380 (100%)	178 (100%)	0	0	10 (3%)	4 (2%)	0	572
2007	380 (100%)	178 (100%)	0	0	10 (3%)	4 (2%)	0	572
Total	**2656**	**923**	**18**	**29**	**562**	**111**	**28**	**4330**

Table 5: Summary of Improvements to PLGS Replacement Feeders.

	Improvement	Expected Benefit
Material	**Piping and weld wire shall be alloyed with >0.3wt%Cr**	Reduce the FAC rate by >50%
	Pipe made with aluminium-killed steel	Reduce free nitrogen believed to lower the likelihood of creep cracking
	Steel-making processes that produce cleaner steel (low S, P, inclusion content)	Improved and consistent fracture toughness
Fabrication and Installation	**2" piping increased thickness by 0.050"**	Increases FAC margins
	Pipe cold-bending procedure with a compressive boost	Reduce ovality and variability in material properties and wall thickness
	Piping manufactured to the requirements of SA106 Grade C instead of Grade B	Take advantage of higher allowable stresses
	All bends (and swages) shall be stress relieved	Significant decrease in residual tensile stresses, considered a primary factor driving cracking
	No localized through-thickness weld repairs permitted	Prevent high residual stresses that can increase the likelihood of cracking
	Automatic process for all welding	Low rate and extent of weld repairs
	Improved control on grinding of welds	Maintain FAC margins
	Heat straightening not permitted for feeder alignment	Prevent formation of unacceptable microstructures

with improved materials" will be the primary feeder management strategy. By replacing the entire feeder assembly with the improved materials described in the preceding section, NBPN believes there will be no life-limiting feeder degradation during post-refurbishment operation. FAC will continue to be active but the higher chromium content will prevent life-limiting rates. Cracking will be prevented, primarily by stress relieving bends. The justification for this will be captured in a COG technical basis document for consistency among utilities with similar feeder material.

NBPN plans to discontinue using a Feeder Piping Management Plan after refurbishment and will include all feeder inspection activities in the periodic inspection plan (PIP). Table 6 compares the planned inspection scope with CSA N285.4-05 minimum requirements. The planned scope exceeds CSA requirements mainly for insurance against any unforeseen degradation. An extensive wall

Table 6: PLGS Post-Refurbishment Feeder Inspection Plans.

Scope	CSA Minimum Requirement	PLGS Plan
Wall thickness Inspection for Wall thinning		
Baseline	20 inlet and 20 outlet	100% outlet, 25% inlet 1st and 2nd bends 100% outlet, 25% inlet adjacent to Grayloc hub
PIP	10 inlet and 10 outlet at 6 year intervals	~50 1st and 2nd bends, ~50 adjacent to the Grayloc hub at 6 year intervals. Focus on outlets
Visual Inspection for Loss of Configuration		
Baseline	Baseline of all areas	100% general visual, seismic restraints, cantilevers spacers, spring cans
PIP	One quadrant general plus 10 feeders detailed at 10 year intervals	25% of above at 10 year intervals
Ultrasonic Volumetric Inspection for Cracks		
Baseline	No code requirement	25% tight radius, high angle outlet bends
PIP	Develop an inspection program if cracking is assessed to be credible	~50 outlet tight radius, high angle bends at 6 year intervals, starting after ≤12 years

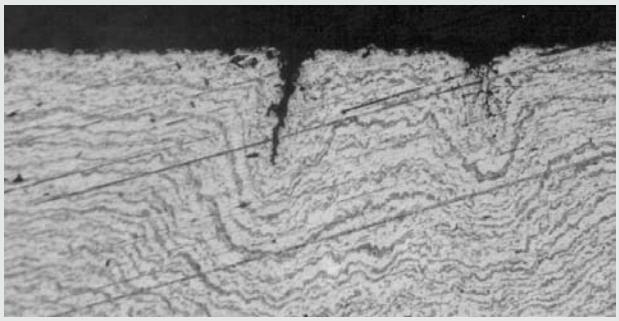


Figure 13: Benign manufacturing features in PLGS replacement feeder piping (maximum depth 200μm).

Table 7: Post-Refurbishment Secondary Feeder Management Activities.

Mechanism	Management Activities
Active Degradation	
FAC	Inspection - wall thickness
	Chemistry control - pHa
Plausible or Postulated Degradation[2]	
Intergranular Cracking	Inspection - volumetric
	Leak Detection & Response
	Chemistry control - oxidants
Fretting	Inspection - visual
	Configuration Management Inspection
Fatigue cracking	Inspection - volumetric
	Configuration Management
	Leak Detection & Response

thickness baseline is included because a known initial thickness eliminates significant uncertainty when assessing wall thinning rate, if required later on. A limited inspection for feeder cracks is included even though stress relieved bends are very unlikely to crack. This inspection is considered to be an added measure to ensure high stakeholder confidence in reliable post-refurbishment operation, in view of the unique PLGS cracking OPEX in the past ten years. A partial baseline crack inspection is also included because some manufacturing features were observed in the replacement feeders (Figure 13), which caused rejectable crack indications using the COG in-service crack inspection procedure. These features were assessed to be benign and baseline results will prevent them from causing false positive indications in future crack inspections.

NBPN will continue to use other secondary management activities, listed in Table 7, for validation and defense-in-depth.

5. Concluding Remarks

The experience of managing PLGS feeder degradation in the past ten years has been challenging and costly but it has also brought benefits. In response to the severity of feeder degradation, NBPN aggressively developed and adopted some effective management activities that may not have been considered at that time, or considered at all. The concept of risk-reduction to evaluate management activities, the use of pre-planned responses to inspection results, and the use of probabilistic safety evaluations to quantify the nuclear safety risk of degradation are a few examples. These activities to manage feeder degradation led to safe, reliable operation until 2008. They are now being successfully applied to manage degradation issues in other areas of the plant [11].

2 PLGS equipment program plans list some forms of degradation considered very unlikely of occurring as plausible or postulated, to define ageing management activities for reasons in addition to reducing risk (e.g. to meet license requirements, increase stakeholder confidence, and other reasons specific to PLGS). In this table, intergranular and fatigue cracking are considered very unlikely.

On the other hand, NBPN has no wish to repeat the feeder degradation experience and is taking extra precautions to prevent life-limiting degradation during post-refurbishment operation. The primary defence is to replace the feeder assembly with components that are not susceptible to intergranular cracking and are more resistant to FAC. NBPN believes this approach will be successful so this paper should be our 'last look' at PLGS life-limiting feeder degradation[3].

6. Acknowledgements

The authors would like to acknowledge the following significant contributions to the understanding and management of PLGS feeder degradation: COG FIJP and its members for collaborative research, tool development, and shared OPEX; dedicated and expert contractors (AECL for feeder repair, assessment, examination, and improved feeder design, Technico for feeder inspection, DEI for probabilistic safety evaluations and other assessments, Kinectrics for burst testing and examinations); Hydro Quebec for sharing expert inspection staff and tools; CNSC staff for many valuable insights; other utilities for providing best practices and lessons learned during benchmarking visits; NBPN management for unwavering support and safety culture; and PLGS Trailer 7 staff for key contributions to feeder management. The eventual treatment of feeders as "planned maintenance" would not have been possible without these contributions.

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3 Others may wish to look further at seven PLGS outlet feeder sections that have been removed and set aside for use by COG. These are feeders N12a, removed in 2007 with partial through wall cracking plus six others removed during the Refurbishment Outage.

A Trolley Mounted Magazine For Reactor Maintenance

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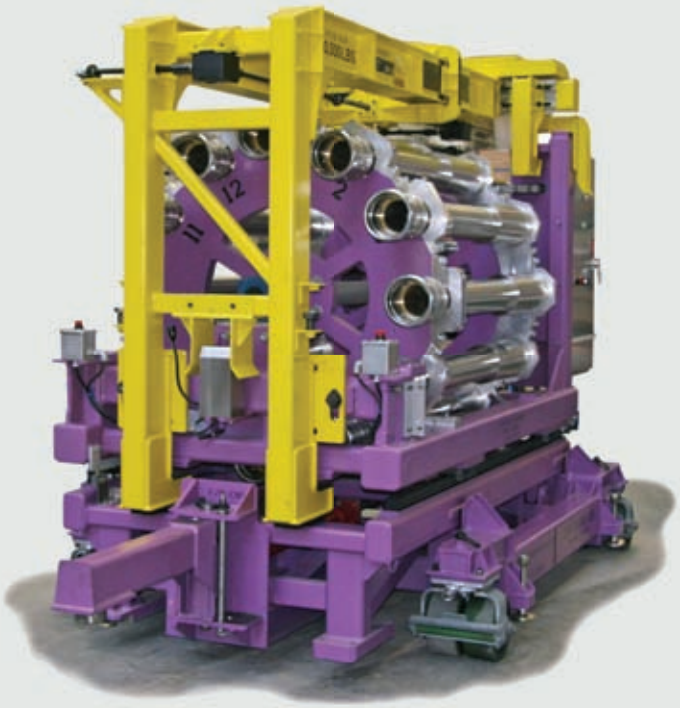
[Ed. Note: The following paper was presented at the 8th International Conference on CANDU Maintenance in Toronto, Ontario, Canada on November 16-18, 2008.]

Abstract

This paper describes the design of a mechanism incorporating a rotary magazine to be mounted on a fuelling machine transport trolley for use at a Darlington reactor during a feeder replacement or maintenance outage. The magazine stores reactor channel maintenance components, such as channel isolation plugs and vented closure plugs, in twelve available magazine channels. Use of the magazine rather than a fuelling machine reduces the time required to transfer such components between the Central Service Area and reactor channels. Component transfers are accomplished by locking the fuelling machine onto one of the magazine channels and using a local controller to execute commands received from the fuel handling control system.



1. Introduction

Reactor channel feeder pipes at Darlington N.G.S. have shown signs of local erosion over the life of the reactors. A feeder replacement program has been implemented by Ontario Power Generation (OPG) to cut and replace the affected sections of feeder pipes. To facilitate this, portions of the target feeders and respective channel end fittings must be temporarily isolated from the primary heat transport system. This is achieved by first defuelling the channel, then exchanging the reactor shield plug (SP) and channel closure (CP) with a channel isolation plug (CIP) and a modified (vented) closure (VCP), using the fuelling machine (FM). The target feeder pipe is then frozen off at a strategic location on the header side of the defect. During the freezing operation, the VCP will be manually operated to relieve pressure without the FM present. After the freezing operation, the VCP is used to manually drain the isolated portion between the CIP and the ice plug to allow the feeder cutting and welding operations to commence.

In early 2007, GE-Hitachi Nuclear Energy Canada (GEH) was commissioned by Inspection, Maintenance and Commercial Services (IM&CS) division of Ontario Power Generation to conceive and develop the means for manipulating these components using the FM on a transport trolley at the target reactor. In addition, a means of protecting the reactor shield plugs against oxidization was required.

To facilitate the manipulation of the SP's, CP's, CIP's and VCP's during feeder replacement campaigns, the Trolley Mounted Magazine (TMM), a twelve-channel rotary magazine apparatus, is installed on the trolley in front of the FM. As directed by commands from the fuel handling (FH) control system, the FM can travel between the TMM and a reactor channel to exchange components as required.

Once the component exchanges are complete, the SP's and CP's remain in the TMM channels, either on or off the trolley, until they are to be returned to the reactor in a typical manner.

The TMM's greater storage capacity over that of the FM means time saved in fewer trolley runs between a reactor and the Central Service Area. This arrangement also reduces radiation dose, as manual shield plug handling is not required.

2. System Description and Arrangement

As shown in Figure 1, the TMM is a twelve-channel rotary magazine apparatus that is installed on the trolley such that the top channel is laterally and vertically aligned with the centreline of the FM snout.

When the TMM upper frame is in the fully extended position (i.e., toward the FM) the TMM channel E-face is axially aligned with an uncrept "A" type reactor end fitting. To accommodate

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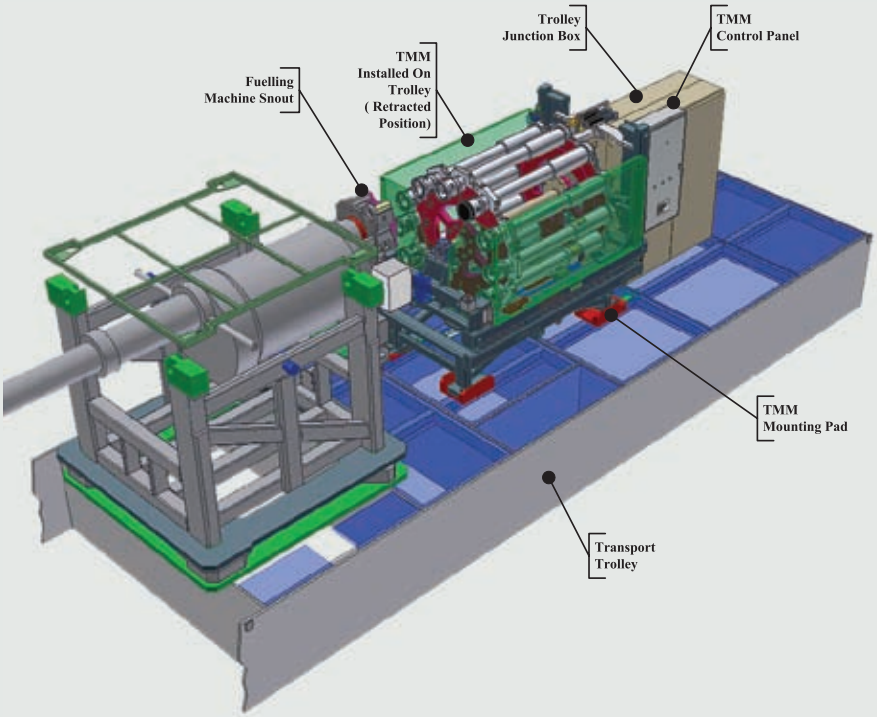


Figure 1: TMM Shown on Transport Trolley with FM

FM seal ring maintenance, the TMM upper frame assembly can be axially retracted to its transportation and storage position (Figure 1).

The TMM functions include:

- Transportation of up to twelve CIPs and VCPs from the Central Service Area to a reactor using the Transport Trolley.
- Interaction with the FM to exchange channel components. After homing and locking onto the active (top-dead-centre) TMM channel, the FM exchanges a VCP and CIP for a CP and SP. Once the feeder replacement operations are complete, the FM returns the CPs and SPs to the reactor channel and the VCPs and CIPs to the TMM.
- A Purge system that vacuum boils residual water off the SP, then floods the TMM channel with low-pressure nitrogen to prevent oxidation of the SP.

3. Mechanical Description

The TMM has an overall envelope of 63.5 inches wide by 125.25 inches long by 82.5 inches high. It has a tare weight of 11,000 lb and is capable of carrying a maximum payload of 2,500 lb (i.e., 12 SPs and 12 CPs).

The TMM consists of five main sub assemblies, as discussed below.

3.1 Lower Frame Assembly

The lower frame assembly, as shown in Figure 2, is a structural weldment that consists primarily of hollow structural steel members. Its function is to locate and support the TMM upper frame assembly on the trolley and provide the TMM axial motion.

A ¼ hp AC motor is attached to a ball screw mechanism at the TMM lower frame to retract the TMM upper frame on the rail system. This provides sufficient separation between the TMM and the FM for maintenance purposes. This mechanism is operated by local controls that are located on the control panel (as discussed in section 4).

The lower frame also provides locating/restraint hardware for interfacing with the TMM Transportation Cart as discussed in section 5.2.

3.2 Upper Frame Assembly

The upper frame assembly, as shown in Figures 2 and 3, is a structural weldment that consists primarily of hollow structural steel members. Its function is to support and align the magazine assembly and the Purge system.

The upper frame is mounted on four linear bearings attached to the lower frame assembly, and supports the following components:

- Magazine assembly (discussed in section 3.3)
- Rotary drive motor (discussed in section 4)
- Hose Connect and Channel Contents linear actuators (discussed in section 4)
- Vacuum/nitrogen (Purge) system (discussed in section 3.5)
- Front and rear cameras (discussed in section 4.1)
- Control devices (discussed in section 4)
- Removable Lexan guard system (Figure 2)

The upper frame also provides locating/restraint hardware for interfacing with the TMM Lifting Beam and Transportation Cart.

3.3 Magazine Assembly

The magazine assembly is a circular array of twelve channel assemblies as shown in Figure 3. Each assembly is clamped into a front and rear (aluminum) magazine plate that positions and axially restrains each channel. The magazine plates are supported by a centre shaft, which is constrained by two commercially available roller bearing housing assemblies.

The twelve front channel clamps are spring loaded with disc springs that allow the channel to rotate and deflect up to .38 inches in the X-Y plane during FM clamp up. This compliance simulates the ability of a reactor end fitting to flex, due to its longer length and restraint geometry.

The rear channel clamp arrangements position and restrain each channel axially and radially.

3.4 Channel Assembly

The TMM channel assembly is typical of a reactor end fitting as it provides an interface for FM clamp up and accommodates

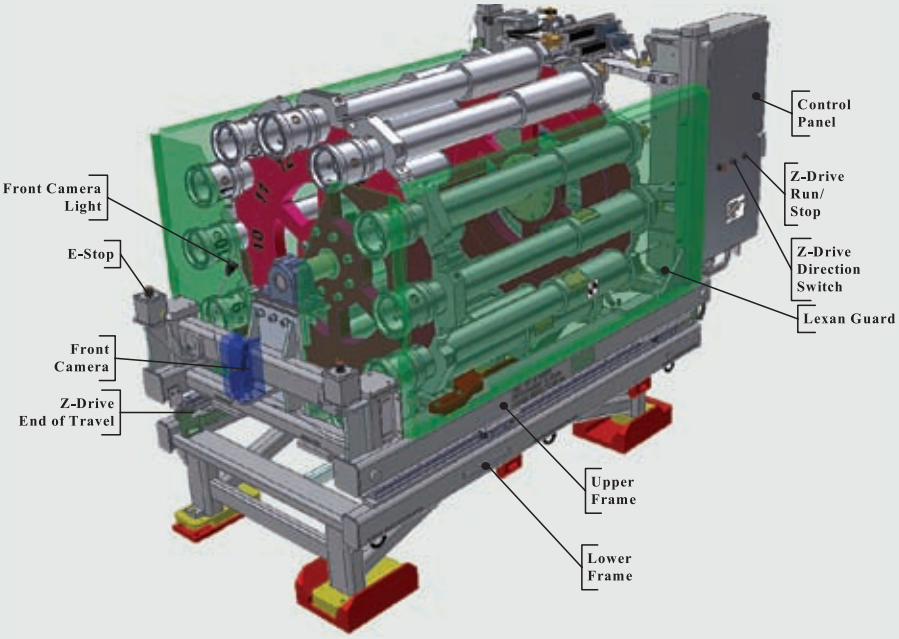


Figure 2: TMM General Assembly

the installation and removal of CPs, CIPs, SPs and VCPs.

All of the channel components are sealed with appropriate o-rings to ensure an airtight design (necessary for vacuum drying and nitrogen retention). As illustrated in Figure 4, the channel itself is a two-piece stainless steel assembly that consists of the channel end and channel body.

The channel end has a typical chrome-plated outer profile that accommodates FM homing and locking operations. The inner profile that interfaces with the FM seal ring is slightly relieved to reduce FM clamping loads, thereby reducing wear on the FM and seal ring. The inner profile that interfaces with the CP or VCP uses four aluminum bronze pins in place of the very complex and expensive 16-lug breech design. The removable pins are profiled to make tangential contact over a very short distance along the flanks of four of the sixteen closure lugs. This arrangement provides the same geometric function as the breech lugs in terms of radially and axially positioning the closure, however do not provide the same strength as the lugs.

At assembly, an aluminum bronze seal ring is clamped between the two channel sections. The seal ring has a specially molded polyurethane seal ring that simulates the end fitting seal face. When the CP or VCP is installed into the TMM channel at the reduced torque (from 250 lb-ft to 150 lb-ft), the seal disc (seal face) presses into the elastomeric ring, thereby isolating the main bore of the channel to accommodate the vacuum drying and nitrogen injection operations.

To ensure that the FM cannot accidentally pressurize the TMM channel, the channel end is vented to the atmosphere by a .5 inch diameter vent hole which is drilled through the wall of the channel end.

To accommodate locking SPs and CIPs into the TMM channel (typical of a reactor end fitting installation), the TMM channel uses the same inside diameter as an end fitting liner and has a similar locking lug arrangement.

The end of the channel assembly opposite the FM is sealed with an end cap assembly as shown in Figures 4 and 5. The assembly consists of a plunger rod assembly that registers off the reactor end of the various length components to provide a visual indication of the channel contents. As illustrated in Figure 6, the indicator disc, which is attached to the outboard end of the plunger rod, will align with the appropriate groove in the indicator rod (i.e., an empty channel, an inlet SP, an outlet SP, an inlet CIP, or an outlet CIP). The position of the indicator disc against the indicator rod can be viewed remotely using the rear TMM camera, or locally from the left side of the TMM (as viewed from the FM).

Also attached to the channel end cap is a special purpose bleed valve assembly. The spring-loaded valve, which is normally closed, provides a means of accessing the sealed channel during TMM operation for the vacuum drying and nitrogen injection operation (further discussed in section 3.5).

One of the major design challenges encountered was a concern that the FM would encounter significantly higher loads during end fitting clamp up due to the stiffness of the TMM channel. In order to accommodate the spatial limitations of the trolley, the TMM channel was considerably shorter than that of a reactor end fitting, and therefore could not bend to provide the typical lateral (XY) compliance of approximately .4

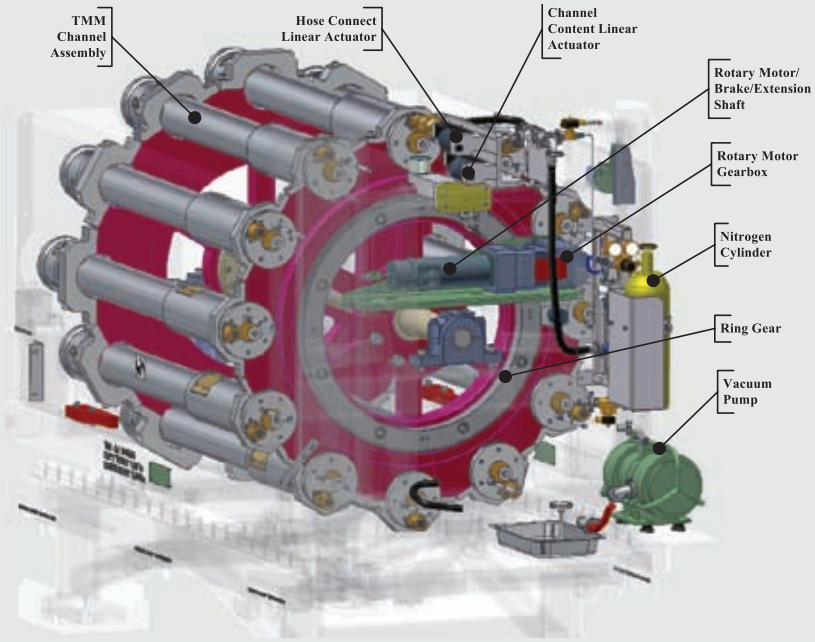


Figure 3: TMM Assembly – Rear View
(The TMM Upper and Lower frames are shown in phantom for clarity)

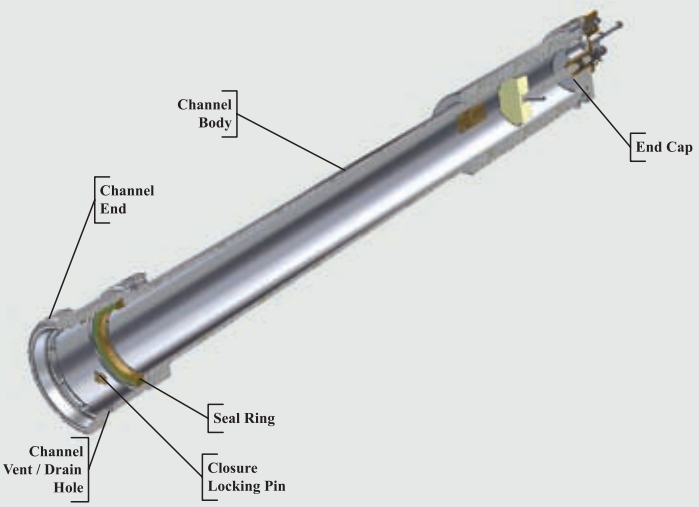


Figure 4: TMM Channel (Sectioned View)

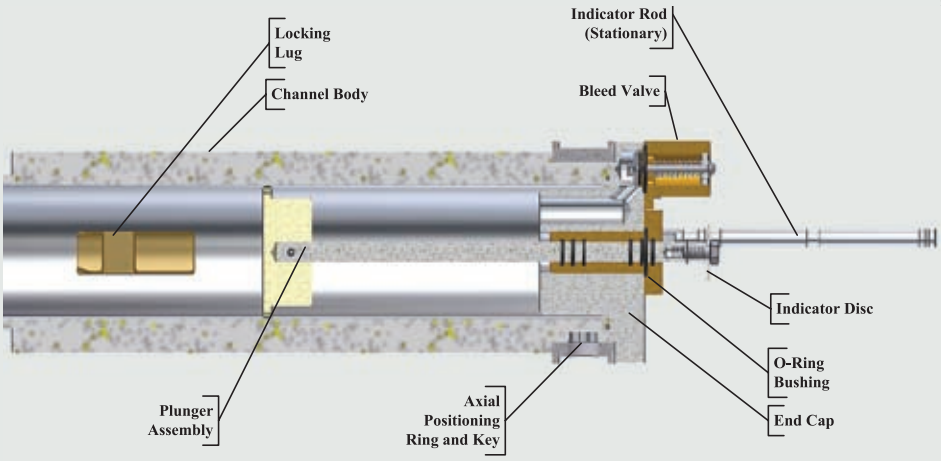


Figure 5: TMM Channel (Section View Close Up)

inches. To solve this problem, the FM end of each channel was mounted in four preloaded spring packs to simulate the flexibility of a reactor end fitting.

3.5 Purge System

As discussed in section 1, during one exchange cycle a reactor SP and CP are exchanged with a CIP and VCP using the FM. The CP and wet SP are carried to, and installed into, the active TMM channel for short-term storage. Once the wet SP is installed, the channel is sealed with the CP and the FM disengages from the channel. To prevent rusting during storage, the SP is vacuum-dried within minutes of being installed. Once dried, the channel is filled with nitrogen at atmospheric pressure to ensure that the SP is protected from oxidization. The entire drying process, including nitrogen injection, requires approximately forty minutes for a channel.

4. Control Description

A Galil DMC-4040 4-axis motion controller, installed in the TMM electrical panel, is used to control the three drives, vacuum pump, and valves. The controller runs stand-alone, with no supervisory control from outside the reactor vault. The entire control application is stored on the device along with data arrays containing target magazine active channel positions and Channel Contents drive stall positions. Commands are sent to the controller from the FH control system over a parallel link. In this way the TMM is remotely commanded to index the rotary magazine by one channel (clockwise or counter-clockwise), run a Purge cycle on the active channel, or advance the Channel Contents linear actuator to stall the plunger rod against a component in the active channel.

The three drives managed by the controller are the magazine rotary drive and two linear actuators.

The magazine drive is capable of providing 30 percent more torque than required to accommodate a worst-case unbalanced magazine load and still meet or exceed positioning and speed requirements. A 16-bit multi-turn absolute encoder is used to perform end-point backlash compensation and to establish the state of an incremental encoder used for position feedback. The absolute encoder is driven by an anti-backlash gear mounted on the magazine ring gear.

The linear drives include the Hose Connect actuator, used to advance the vacuum/nitrogen manifold block to mate with the bleed valve and seal on the active channel (Figure 6), and the Channel Contents actuator, used to extend the plunger rod into the active channel to stall against either an installed component or to indicate an empty channel. Normal operation requires the rod to be pushed to the empty channel position and then back-driven as the FM installs a component in the channel. A spacer mounted on the outboard end of the plunger rod thereby aligns with markings on the fixed indicator rod to identify the component installed in the channel. The rear camera view shows this alignment to the FH operator (Figure 6).

A Z motor, not controlled by the Galil unit, is used to retract the upper frame to provide sufficient separation between the TMM and the FM for maintenance purposes. Control of this motor is by hand switches mounted on the TMM electrical panel door.

Two operating modes, Production and Maintenance, are available for controlling the TMM.

Production Mode is the normal at-reactor operating mode for the TMM. In this mode, the machine is controlled remotely, as described previously, from the FH control system under the supervision of the FH operator, or locally by an operator using a hand-held pendant. When connected to the FH system, this mode allows indexing the magazine clockwise or counter-clockwise to move the next channel to the active position, performing the Purge cycle on the active channel, or advancing the plunger rod with the Channel Contents actuator. When connected to the local pendant, Production Mode includes all the remote commands, but also the ability to independently

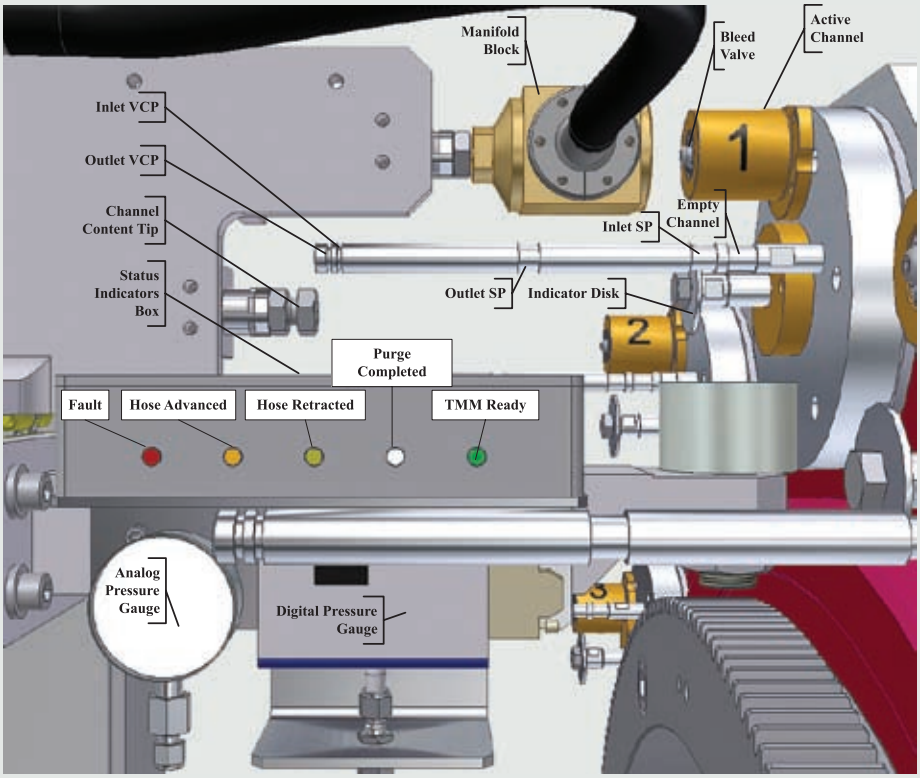


Figure 6: TMM Rear Camera View

advance or retract the Hose Connect actuator, which is used in the Purge cycle.

Maintenance Mode requires connection to the hand-held pendant and the installation of a wire jumper in the electrical panel. This mode allows a local operator to jog the magazine drive at high or low speed and store channel positions in the local controller's non-volatile memory to support calibration of the magazine encoder.

4.1 Interfaces

The primary FH operator interface consists of CCTV views provided by two cameras located at either end of the TMM. These views provide confirmation of controller process state (via status lamps), magazine position, active channel number, and channel contents. A coaxial switch located within the TMM electrical panel allows the FH operator to select the front or rear camera view. The status lamps viewed on the CCTV monitor indicate Fault, Hose Advanced, Hose Retracted, Purge Complete, and TMM Ready (Figure 6). A fault declared by the controller application remains in effect until the controller receives another command. The new command is executed unless the fault persists. Because this is a standalone controller on the transport trolley, the FH operator is generally given the opportunity to attempt to resolve a fault condition by issuing a new command. The Hose Advanced, Hose Retracted, and Purge Complete lamps, along with the pressure gauges, provide assurance that the Purge cycle is running properly. In Production Mode, the TMM Ready lamp indicates that the magazine drive is stopped (with brake engaged), a channel is in the active position, the active channel number is available to be read by the FH controller, and no other tasks are running. Without this signal, the FH controller cannot advance the FM or if advanced, the FM cannot install or remove channel components.

A parallel connection is used to transfer the active channel number to the FH controller. Aside from the CCTV views, the FH operator is presented with a graphical image of the magazine and channel contents as part of the FH control display system. The active channel number transmitted from the TMM controller is used to update the magazine image following completion of a magazine index command. The displayed channel contents are presently updated based on data entered by the FH operator. The TMM control design supports the future capability to transmit a component code, determined by the plunger rod stall position, to the FH controller to make this display update automatic.

A serial communication link connects the local TMM controller to a port located in the Common Equipment Room adjacent to the main control room. A technician can use this port to examine the logic in the TMM controller for troubleshooting purposes. This is the preferred method for interrogating the controller under a fault condition during operation at a reactor. The alternative is to use an Ethernet connection locally at the TMM controller. The controller maintains an array of the most recent fault codes, which can only be determined through such a direct link.

4.2 Safety Interlocks

The following interlocks are implemented in hardware:

- The magazine cannot be rotated unless both linear actuators are fully retracted.
- The linear actuators cannot operate if the magazine brake is not engaged.
- None of the motors (magazine, linear actuators, or Z), solenoid valves, or vacuum pump can be operated if the E-Stop circuit is activated.
- An E-Stop trips an electronic lock-out input on the controller, thereby shutting down the drive amplifiers at the hardware level, effectively disabling the magazine and two linear actuator motors.

In addition to the hardwired interlocks, logic in the TMM controller inhibits operation of a control function unless certain interlock conditions are satisfied. For example, the Hose Connect actuator is not permitted to advance unless the magazine rotary drive is stopped, a magazine channel is in the active position, TMM is in Production or Maintenance Mode, and no general fault exists.

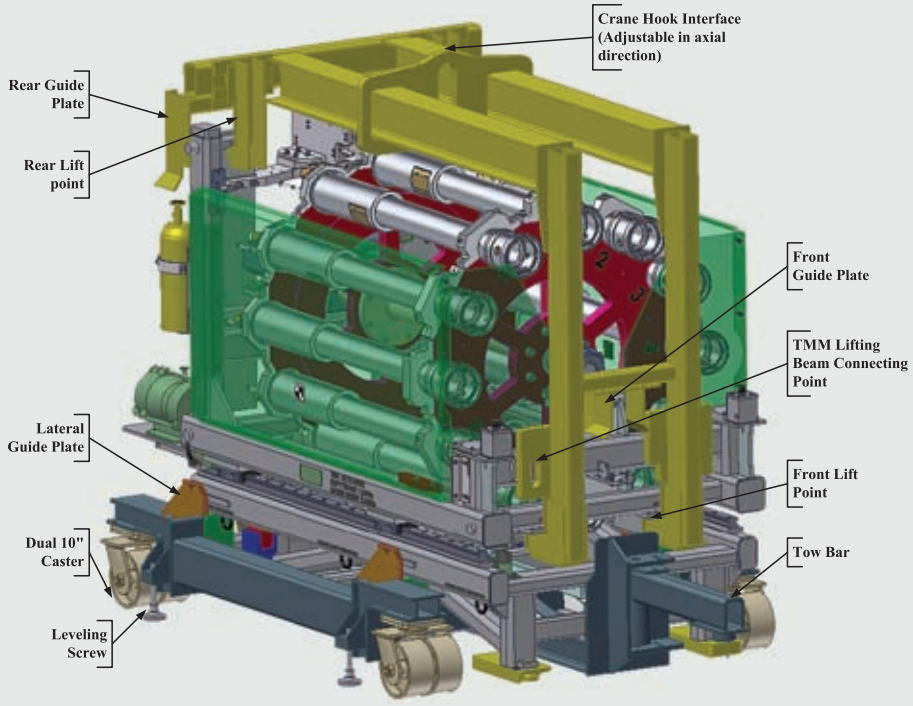


Figure 7: TMM with Lifting Beam and Transportation Cart

5 Special Purpose Components

5.1 Lifting Beam

The TMM Lifting Beam (Figure 7) is a structural weldment that is designed to lift the fully loaded TMM with or without the TMM Transportation Cart. The assembly has a tare weight of 2,400 lb and a lifting capacity of 20,000 lb. When installed onto the TMM, it adds 14.5 inches of height for a total vertical envelope of 100 inches. The lifting beam has an adjustable lift point that provides ±8 inches of travel in the axial (FM Z) direction to accommodate various load conditions (i.e., variations between TMM empty or full, TMM with or without the Transportation Cart, and beam empty). The lift point adjustment can be easily performed by one operator from floor (or trolley) level.

Four feet on the lifting beam provide lifting points that interface with the TMM. Guide pads are provided at each end of the beam to safely locate the beam and ensure that TMM components are not damaged during installation or removal. When the lifting beam is being manoeuvred into its lift position, four stationary lifting arms are positioned under lift points within the TMM upper frame. Once positioned, two bolts (that are not within the load path) are installed to lock the beam in place. The time required to install or remove the lifting beam (including set up) is less than 5 minutes.

5.2 Transportation Cart

The TMM Transportation Cart (Figure 7) is a structural weldment that is designed to support a fully loaded TMM with the Lifting Beam installed. The assembly has a tare weight of 3,300 lb and a carrying capacity of 20,000 lb. The cart is 84 inches wide by 130 inches long, and adds 4 inches to the total TMM / TMM Lifting Beam height envelope (104 inches total).

The cart is supported by four polyurethane dual lockable swivel casters and has 4 inches of ground clearance. Both ends of the cart have a removable lockable tow bar that can be folded in to reduce the overall cart length. Side and end guide plates are strategically located to ensure that TMM components are not damaged during installation or removal. The cart also provides a four-point interface for lifting, either with or without the TMM installed. The time required to install or remove the TMM is less than five minutes.

6. Alternatives Considered

A number of design alternatives were considered in the initial design stages. The two primary alternatives were abandoned because of cost and schedule concerns. One concept used a continuous chain conveyor arrangement with 24 reactor end fittings arranged in a "D" shape. One of the positions would include a drive that would temporarily move the end fitting out of formation toward centre to provide FM alignment and snout clearance. Another concept involved a double circular array of 16 outer channels and 12 inner channels. This would have required the top-dead-centre channel be advanced toward the FM to provide snout clearances. A vertical drive would have also been required to elevate the inner channel pitch to the FM centreline.

Given the accelerated schedule and budget constraints, it was necessary to keep the design as basic as possible, have ongoing customer support and involvement, and leverage past experience and proven technology wherever practical.

7. Summary

The TMM represents a lean design that addresses the need for improved efficiency in transferring channel components between a reactor and the Central Service Area to support the feeder replacement project at Darlington N.G.S.

Several aspects of this paper focus on solutions for creating a minimal design that satisfies a number of sophisticated requirements. In that respect, lessons learned from previous projects and special simplifications were incorporated. In particular:

- The magazine drive was designed to use a large ring gear/servo drive arrangement similar to that used successfully for the Darlington Universal Delivery Machine magazine.
- Past success with the Pickering UDM transporter and the Darlington and Bruce UDMs and Fuelling Machine Tool Stations (FMTS) provided valuable lessons when addressing critical spatial clearances during transportation of the TMM through the station and during trolley installation.
- Off-the-shelf technology was used for the vacuum drying/nitrogen injection system while accommodating the added complication of channel indexing. As such, a commercially available linear actuator was used to advance a custom mani-

fold block to seal against a special purpose bleed valve. To keep the design as basic as possible, the same piping and hardware were used to deliver the low-pressure nitrogen.

- A relatively low-cost, robust digital controller was installed local to the apparatus, i.e., within containment. The control application therefore had to be compact and fault tolerant. A simple serial connection to the Common Equipment Room was added to allow remote troubleshooting under fault conditions.
- A minimalist interface to the FH control room was provided, relying primarily on CCTV camera views, for monitoring TMM operations. The only graphical interface was provided with an addition to the existing FH control display system.

Although a number of modifications would be required, the design of the Darlington TMM is considered sufficiently flexible to lend itself readily to other stations' needs.

The total design and supply cycle for TMM was fourteen months. Two TMM assemblies, two TMM Transportation Carts, one TMM Lifting Beam, and one TMM Lifting Beam Transportation Cart were delivered to Darlington N.G.S. in early 2008.

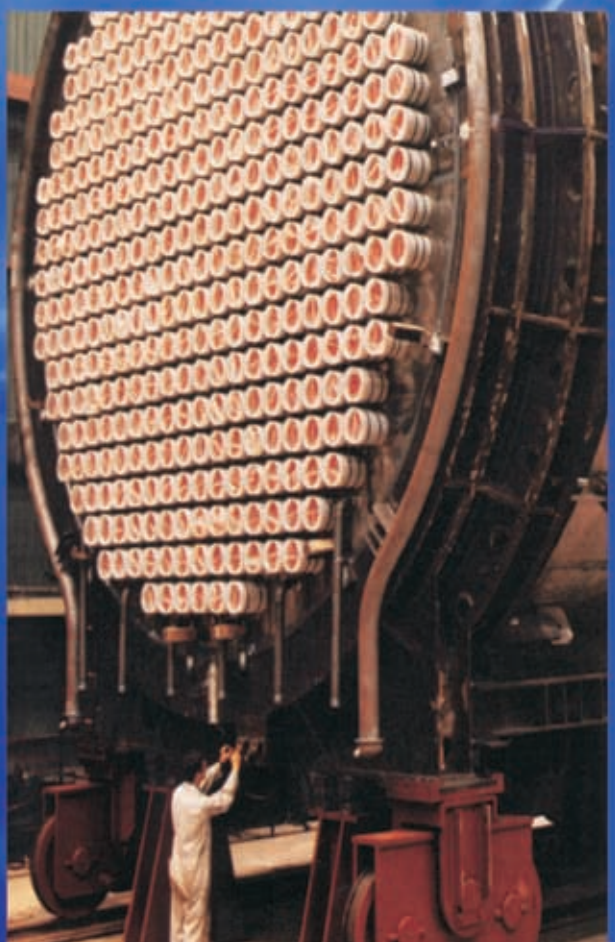
The TMM is currently being commissioned for use in 2009.

8. Acknowledgements

We would like to thank Mike Gray (OPG), Patrick Henry (GEH), David Murray (GEH) and Dave Rayment (GEH) for their assistance during the design phase of this project.

Scenes from the CNA Conference

Maximizing Plant Performance Enhancing Safety



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GENERAL news

(Compiled by Fred Boyd from open sources)

Bids submitted for Darlington new build

On March 3, 2009, Infrastructure Ontario reported that it had received three final bid proposals on the deadline of February 27, 2009, for two new nuclear power plants to be located at the Darlington site of Ontario Power Generation. Reportedly there were over a hundred boxes of documents.

Bid submissions were received from AREVA NP, Atomic Energy of Canada Limited, and Westinghouse for the Nuclear Procurement Project Request for Proposals. The deadline had been extended from the end of 2008. Infrastructure Ontario said this concludes this part of Phase 2 of the RFP process. AREVA has submitted its EPR 1600 MWe design; AECL its ACR 1000 and Westinghouse its AP 1000.

The provincial project is selecting a nuclear vendor based on pre-established commercial terms, including lifetime cost of power, ability to deliver on schedule and level of economic investment.

The next step involves a compliance review and an evaluation of each proposal. It is expected that the preferred vendor will be announced in June. A commercial team, led by Infrastructure Ontario, is managing the procurement process. Team members also include representatives from Bruce Power, Ontario Power Generation, Ministry of Energy and Infrastructure and Ministry of Finance.

An aerial view of Darlington. The new units will be built to the east (upper part of photo) of the existing station.

CNSC corrects exaggerations about tritium leak

In mid February the octogenarian anti-nuclear campaigner, Gordon Edwards, purporting to represent a group called Tritium Awareness Network, issued media releases, about the "trillions of becquerels of tritium being released into the Ottawa" from the Chalk River Laboratory of Atomic Energy of Canada Limited, which were quickly propagated.

He subsequently sent a letter to Michael Binder, President of the Canadian Nuclear Safety Commission, complaining about the Commission's secrecy and lack of action.

Binder responded in a letter, now posted on the CNSC website. Following are some excerpts from that letter.

In your letter of February 16, 2009 you make a number of points that I feel I must respond to.

Both the Canadian Nuclear Safety Commission (CNSC) and Atomic Energy of Canada Limited (AECL) have been clear that the water released within the NRU building was collected and contained. Planned operational tritium releases that are controlled and monitored within environmental standards are not leaks.

I am happy to provide you with the number of becquerels released but it is important to put these numbers in context. The calculated release of tritium through the NRU stack was 4.5 TBq. Such an airborne release could only result in an extremely small dose of radiation to the public, of about one ten-thousandth of the CNSC regulatory maximum public dose of 1 mSv. In comparison, the average Canadian receives about 2.5 mSv from natural background radiation.

The measurements upstream of Chalk River are about 4 Bq/L and those of Petawawa are about 8 Bq/L. I would point out to you that the numbers are well below any comparable standard, including the Canadian drinking water guideline of 7,000, the US drinking water standard of 740 Bq/L or the California Public Health Goal of 15 Bq/L.

Furthermore, CNSC staff has provided detailed information on tritium levels in the Ottawa River at public meetings and CNSC hearings.

In closing, I would like to reiterate that the small leak of heavy water was contained. At no time was the public or the environment at risk.

NEA workshop on medical radioisotopes

At the request of the Government of Canada, the OECD Nuclear Energy Agency (NEA) convened a workshop on the Security of Supply of Medical Radioisotopes in Paris on 29-30 January 2009. The workshop addressed present and future challenges to the reliable supply of Technetium-99m (Tc-99m), a key medical isotope derived from Molybdenum-99 (Mo-99), and to identify measures that should be taken to help ensure supplies in the short, medium and long term. The workshop brought together over 80 participants from 13 OECD countries and 3 non-OECD

countries and from international organisations.

Participants recognised the vulnerability of the global medical isotope supply chain, which depends on a limited number of ageing nuclear research reactors for isotope production and a complex processing and distribution chain for delivery of short-lived isotope products to the health system. In light of the foregoing, participants identified a number of measures to enhance short-term supply security. There was broad agreement that increased transparency among reactor operators, isotope processors and distributors, government regulators, and health care professionals is needed.

Over the longer term replacement of, or supplementing, the ageing reactors that are used to produce Mo-99 is needed. It was recognised that uncertainties regarding the long-term global demand make the decision to invest in capital-intensive additional nuclear capacities difficult.

Participants agreed long-term supply presents a global challenge that will require a global response. There was agreement that governments have a responsibility for establishing an environment conducive to the private and/or public sector investments that may be required.

More information is available on the NEA website www.nea.fr

Final calandria tube removed from Bruce Unit 1

On March 5, 2009, the 480th and final calandria tube was removed from the Bruce A Unit 1 reactor late Wednesday, marking the end of the disassembly phase in the massive project to restart Units 1 and 2 at the Bruce A generating station.

Using custom-designed robotic tools, crews from Atomic Energy of Canada Limited (AECL) were able to complete the calandria tube removal on Unit 1 in 26 days compared to 117 days for Unit 2.

Each unit holds 480 calandria tubes, which lie horizontally inside the reactor and contain the pressure tubes, which in turn hold the uranium fuel bundles. Radioactive after years of service, these tubes were painstakingly removed using a series of robotic tools controlled by trades people working outside the reactor vault in a control centre outfitted with video feeds and computers to manipulate the tools.

To complete this phase of the restart, a specialized tool was latched onto the west face of each reactor so it could push the tubes, one at a time, while another tool pulled from the opposite end. Guided into transfer cans, which served as contamination barriers, the six-metre long tubes were then picked up by a crane-like Remote Tool Carrier and swung onto narrow pallets.

To minimize the amount of radioactive waste, the tubes were then fed into a special press, which crushed and cut the tubes into small pieces about the size of a credit card. Each of these pieces were then carefully stored in custom containers and shipped across site to the Western Waste Management Facility.

With the old calandria tubes now gone, retube crews are preparing the reactor vessels to accept new calandria tubes with an eye to returning both units to service in 2010.

On March 11, 2009 members of the media were invited to participate in an in-plant tour of the Bruce A generating station to visit the Retube Control Centre and the reactor vault along with Bruce Power CEO Duncan Hawthorne and Restart Project Senior VP John Sauger.

For stories and video clips on all aspects of the project, see the Bruce A Restart web pages at www.brucepower.com.

Endface of Bruce A Unit 1

ACR passes CNSC initial design review

At the end of 2008, the Canadian Nuclear Safety Commission announced that it had completed Phase 1 of the pre-project review of Atomic Energy of Canada Limited's new Advanced CANDU Reactor, ACR-1000 and concluded that, "at an overall level the design intent is compliant with CNSC regulatory requirements and meets the expectations for new nuclear power plants in Canada". Further, it stated, "CNSC staff did not find any issues that would lead to significant design changes".

CNSC offers pre-project design reviews to any organization requesting it and paying for it. A review of ACR had begun in 2007 but was halted by CNSC's previous president Linda Keen. AECL applied again in April 2008.

The CNSC pre-project reviews are in two phases. Phase 1 is an overall assessment of the design against the most recent CNSC design requirements. Phase 2 goes further into details with a focus on identifying any potential fundamental barriers to licensing the design.

AREVA and Westinghouse have both submitted the designs which they proposing to Ontario, EPR and AP 1000. CNSC has scheduled the AP 1000 Phase 1 Review to be completed in November 2009 and the EPR review in February 2010.

New head of SNC Lavalin

Pierre Duhaime has been named as CEO of SNC-Lavalin Group Inc., succeeding Jacques Lamarre who is retiring after 13 years in the position. SNC-Lavalin is Canada's largest engineering and construction company and a global leader in the ownership of infrastructure, and in operations and maintenance services. SNC-Lavalin companies have offices in 30 countries around the world are currently working in about 100 countries.

SNC-Lavalin Nuclear Inc., a member of the Team CANDU consortium, is a wholly owned subsidiary of SNC-Lavalin. Its president is Patrick Lamarre, son of the outgoing CEO of the parent company.

Problems at Cigar Lake continue

There have been further water problems at Cameco's Cigar Lake mine in northern Saskatchewan. No. 1 shaft first flooded in 2006 due to an increase in the rate of water inflow to the mine. In August 2008 Cameco announced that it had temporarily suspended remediation work.

Work on stopping water inflow in the No.1 shaft at Cigar Lake has begun again, but the company expects the work to take most of 2009. Remediation of No.2 shaft continues. Cameco said it had succeeded in sealing the inflow in the shaft and that it anticipated removing all of the water in the shaft in the second quarter of 2009.

Cameco has now said that they no longer anticipate production in 2011 and are assessing the impact of the August inflow on the planned production date and capital cost estimate.

As of the end of 2008 Cameco had incurred $359 million in capital costs on Cigar Lake. It reported that it expects to spend $21 million on the project in 2009.

The company has also reported the completion of a bought deal public offering of over 26 million common shares providing net proceeds of $440 million. The issue price was $17.50 slightly below the prices on the TSX in February

Cameco announced in August 2008 that it had temporarily suspended remediation work at the No.1 shaft at its Cigar Lake uranium project in northern Saskatchewan, which flooded in 2006, due to an increase in the rate of water inflow to the mine.

Cigar Lake is one of the world's most promising uranium deposits, with estimated reserves of 113 million pounds of U3O8 at grades as high as 20.7%. A consortium of Cameco, holding 50% of the project, Areva Resources Canada (37%), Idemitsu Canada Resources (8%) and Tepco Resources (5%) has been developing the deposit in the north of Canada's province of Saskatchewan. Originally, the mine was expected to begin operating in early 2008.

Cameco has now said that they no longer anticipate production in 2011. It noted that there can be no assurance as to when production will commence or that other occurrences will not further delay production.

The company said that work on stopping water inflow in the No.1 shaft at Cigar Lake had started, but it expects the work to "take most of 2009." Remediation of No.2 shaft continues. Cameco said it had succeeded in sealing the inflow in the shaft and that it anticipated removing all of the water in the shaft in the second quarter of 2009.

L-3 MAPPS to Replace Point Lepreau DCC Computers

L-3 MAPPS has secured an order from New Brunswick (NB) Power Nuclear for new digital control computer (DCC) central processing units (CPUs) at the Point Lepreau Generating Station. In addition, L-3 MAPPS will supply a new DCC test system based on the design of a unit that L-3 MAPPS developed for the CANDU* Owners Group.

DCC systems are used to monitor and control the major reactor and power plant functions at CANDU nuclear power plants.

Using SSCI-890 technology, L-3's DCC CPUs will replace four Varian 73 computer systems and related input/output and ancillary equipment currently in use at Point Lepreau. In addition to the test system, L-3 MAPPS will provide spare parts, including circuit boards, power supplies and integrated circuits, to maintain the test system for five years. The products will be delivered to Point Lepreau toward the end of 2009.

For further information go to the L-3 MZAPPS website: www.L-3com.com/MAPPS.

CNSC approves EA for Pickering B refurbishment

At the end of January 2009, the Canadian Nuclear Safety Commission announced its decision on the environmental assessment for the proposed refurbishment of the Pickering B station. The CNSC concluded that the refurbishment and continued operation of Pickering B is not likely to cause significant adverse environmental effects, taking into account the identified mitigation measures.

Ontario Power Generation is working with the CNSC to complete an Integrated Safety Review of the plant. This involves the assessment of the current state of the plant and plant performance to identify any factors that would limit safe long-term operation. OPG is also examining the financial impacts of refurbishment on the corporation and ratepayers.

The OPG Board of Directors is expected to make a decision on the refurbishment later in 2009.

Budget for Yucca Mountain project cut

The budget presented by US President Barack Obama at the end of February 2009 slashed the budget for the Yucca Mountain radioactive waste repository project drastically. Representatives of the Department of Energy stated that there will be just enough money to respond to questions posed by the Nuclear Regulatory Commission.

An application to build the Yucca Mountain repository was lodged with the USNRC in June 2008. It is understood that NRC will keep it in its schedule until a firm decision is announced.

Yucca Mountain began with US legislation in 1987 that stipulated the government would provide permanent storage for radioactive wastes by 1998. Nuclear utilities have been contributing to a fund and are now suing the government for recover of those funds.

EA guidelines issued for two projects

The Canadian Nuclear Safety commission and the Canadian environmental Assessment Agency issued statements in January and March that the Final Environmental Impact Statement Guidelines had been issued for the:

- Deep Geologic Repository for Low and Intermediate Level

Radioactive Waste, (at the Bruce site)
and the

- Darlington New Nuclear Power Plant Project

The two organizations also announced Joint Review Panel Agreements for the two projects.

The EIS Guidelines identify the information needed to prepare the Environment Impact Statements and list the requirements for a licence to prepare the site

The JRP Agreements establish how the joint panels will function and describe the terms of reference for conducting the environmental assessment and for considering applications for a licence to prepare the site. The members of the Joint Review Panels had not been announced as of mid March 2009.

Areva acknowledges $2 billion loss on Olkiluoto 3 project

In its financial statements for fiscal year 2008 Areva included a figure of 1.7 billion euros (about $2.8 billion Canadian) as an estimated loss on its project for a 1600 MWe EPR nuclear plant for the Finnish utility TVO and set completion in 2012, three years later than the original schedule.

An arbitration is underway between Areva and TVO in the International Chamber of Commerce as each blames the other for the delays. The Areva-Siemans consortium has asked for a schedule extension and 1 billion euro in compensation while TVO is asking for 2.4 billion euro in damages.

Further, Siemans has stated that it plans to sell its 34% interest in Areva's reactor business.

Then, in early March 2009, Siemans announced an agreement with Russia's Rosatom Corp. to create a joint venture to design, build and operate nuclear power plants. Areva stated that would be a breach of contractual obligations as its 2001 agreement with Siemans contains a non-competition clause.

AECL names new building after G. C. Laurence

In early March 2009 Atomic Energy of Canada Limited (AECL) has officially opened G.C. Laurence Hall, their fourth office building in Deep River. The building will provide space for more than 110 AECL employees and contract workers.

AECL employees were invited to suggest names for the new building, and three employees, Jeremy Whitlock, Karen Colins and Mike English all submitted the same name.

G.C. (George Craig) Laurence, after whom the building is named, was instrumental in the early days of AECL. His contributions to the nuclear industry, spanning more than 40 years served as a foundation for work conducted at the Chalk River Laboratories. During his years of leadership at the Atomic Energy Control Board (now the Canadian Nuclear Safety Commission), he created a climate in which innovative approaches to safety could be developed in ways that enhance both safety and operational efficiency. Laurence Court, a street in Deep River, is also named in his honour.

The new office comes complete with the latest technology, such as more than 20 kilometres of high-speed LAN and IP phones.

OPA proposes new electricity pricing

The Ontario Power Authority announced in early March 2009 that it intends to introduce new electricity pricing to encourage the development of renewable energy from a diverse range of producers including homeowners, community-based groups and larger scale commercial generators.

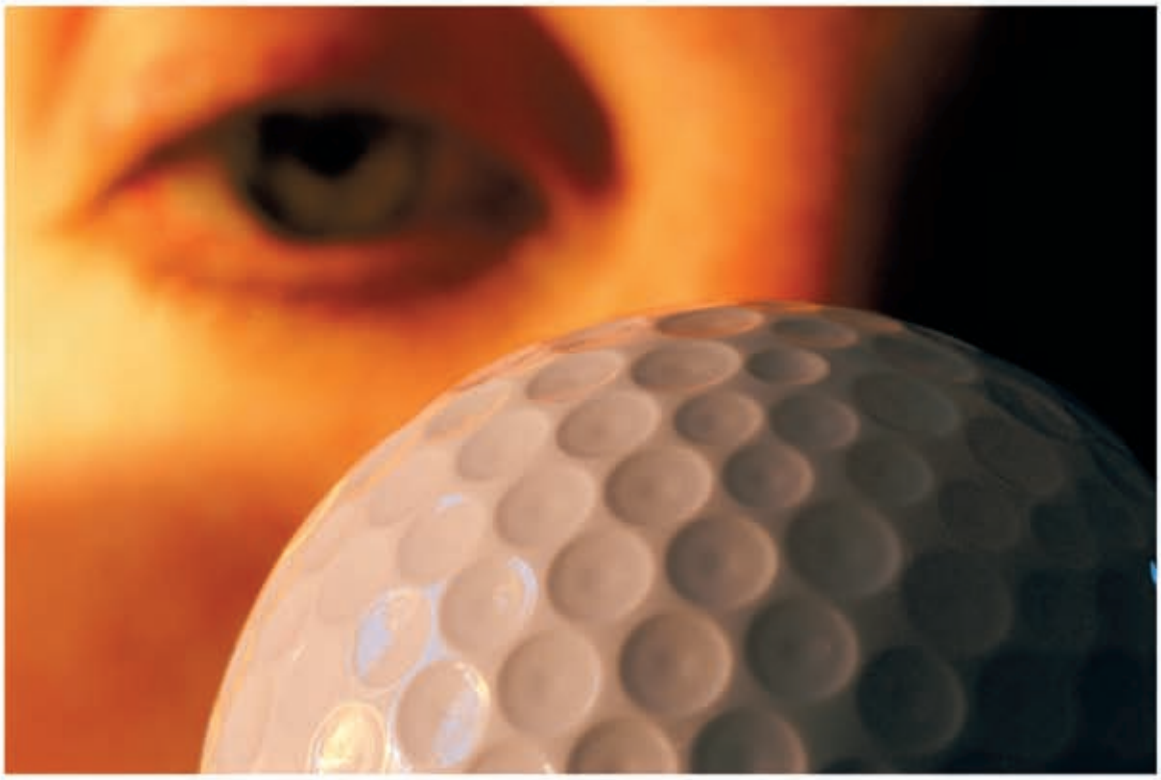
As North America's first guaranteed pricing structure – called a feed-in tariff (FIT) – for various forms of electricity production, it would offer a stable, competitive price combined with a long term contract. A FIT would establish prices for energy generated from renewable sources, including on-shore and off-shore wind, hydroelectric, solar, biogas, biomass and landfill gas. Proposed prices and program guidelines announced today will form the basis of an eight-week consultation process with renewable energy stakeholders and several general information sessions for the interested public.

The proposed FIT prices were developed based on experience here in Ontario and in other jurisdictions. Prices differ based on project size and type of renewable energy technology. They cover capital, operating and maintenance costs and allow for a reasonable rate of return on investment over an approximate 20-year period. They also provide special categories for community-based projects.

Ontario's Energy Supply Mix

Supply Type	Fuel Type	Location	Current/ Proposed Price (kWh)
Peaking fuel for reliability*	8% natural gas	various plants	8.5¢ - 14¢
Renewable Opportunities**	TBD% – new renewables portfolio	wind solar biomass biogas landfill gas new hydro	8¢ - 44.3¢
	1-2% rooftop solar***		53.9¢ - 80.2¢
Baseload 76%	53% nuclear	Pickering Darlington Bruce	6¢ - 7¢
	23% hydroelectric	Niagara Falls St. Lawrence River Northern rivers	5.7¢ - 6.2¢

* Existing supply
** Emerging supply
*** 1% = approximately 100,000 residential rooftops



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CNS news

From the President

One of the pleasures of being President of the Canadian Nuclear Society is being invited to talk to some of the branches at their local meetings. There seems to be an assumption that becoming President implies having something useful or interesting to say, and while this may or may not be true, it's great to have the opportunity to get out to the Branches, and to meet and talk with some of the members. It also gives me an opportunity to tell people about all the good things that the CNS does, the challenges and opportunities we are facing, and where we may be heading in the future. Of course, I can never resist a chance to tell people about my own views on nuclear issues while I have a captive audience! I also appreciate the opportunity to hear the views of some of the members on the various issues coming out of the Task Force on Governance and the Special Session of the Extended Council, which is reported on elsewhere in this issue.

(While there are different views on the degree of success of this Special Session, I believe it was a very useful exercise which brought out valuable input from a wide range of members about future development of the CNS, and I thank all those who made the effort to participate.)

During the past month I have had the opportunity to talk to both the Ottawa Branch and the Chalk River Branch of the Society. While the two Branches are quite different in terms of the composition of their membership, in both instances I received a warm welcome, lots of interesting questions, and useful feedback from the attendees.

One interesting aspect of my visit to the Chalk River Branch was to meet a couple of the younger members of the Society, Daniel and Kathryn Albrecht, who are students at Mackenzie High School in Deep River. I also heard about Akila Senaratne, a student at Morison Public School, who is also a member. It's wonderful to see young students joining the CNS, participating in our meetings, and taking an interest in nuclear matters. Such interest suggests that the future of nuclear technology in Canada will be in good hands.

In early February I accompanied Ben Rouben, our Membership Chair, to the offices of SNC –Lavalin Nuclear in Oakville, to talk to about forty members of the staff about the CNS, our activities, and the benefits of membership. This visit was the result of an invitation from the CEO, Patrick Lamarre, following some discussions about CNS membership at CNA Board meetings which I had attended earlier. I believe that this exercise was useful in spreading information about our Society to nuclear industry people who may not have been aware of all the excellent things that the CNS does. At the CNA Board meeting in Ottawa in February, I volunteered to arrange for similar lunch-time presentations to any other CNA member companies who desire such an exercise.

The CNS continues to grow every year, and our membership is nearly double what it was when we became incorporated as an independent Technical Society in 1998. This is due in large part to the excellent efforts of our Membership Chair. On the other hand, when we consider that there are about 30,000 people employed in the Canadian nuclear industry in one way or another, it is clear that many people in the nuclear field are not motivated to join the Society. I therefore believe that it is worthwhile to make an effort to inform people around the nuclear industry about what we do and the advantages of membership, with a view to broadening our activities and attracting new members into our Society.

CNS Summer Scholarships

The Canadian Nuclear Society is pleased to offer a scholarship to promote nuclear science and engineering in Canadian universities.

This scholarship is designed to support undergraduate summer work projects in nuclear science and engineering at Canadian universities.

Two awards of $5000 are available for the summer of 2009

Each scholarship will be awarded to an undergraduate student for a specific summer work project related to nuclear science and engineering. There must be a faculty member supervising the project.

The awards will be applied as partial payment of each student's earnings during the project period. The faculty supervisor must provide an additional $1500.

Awards will be based on the academic standing of the student and the merit of the proposed project. An independent panel, appointed by the CNS, will review submissions and make award decisions.

For further information contact:

Dr. Adriaan Buijs
McMaster University
Department of Engineering Physics
e-mail: buijsa@mcmaster.ca

The Special Session of the CNS Extended Council

By Ric Fluke

Fifty people attended the Special Session of the CNS Extended Council on 15-16 January 2009 at the Courtyard Marriott Hotel in Toronto. The purpose was to examine the present CNS with the objective of identifying values, a vision, goals, and aspirations for the future as a basis for a definitive 5-Year CNS Strategic Plan.

The need for the session was clear – the CNS was founded in 1979 with 370 "charter" members, and thirty years later we are 1225 strong. Also turning thirty are the founding objectives of our Society, although they were not formally documented until 1998 in the "Letters Patent", available on the CNS Website. The industry is changing rapidly, and so is the nature of our membership. Now is a good time to examine ourselves, where we are and where we want to be. We need to examine if the CNS is serving its membership well, and indeed the industry and the public. From the Prairies to the Maritimes, from university students to retirees, from laypersons to learned physicists, the Special Session was well represented to take on this task.

With diversity of participants comes diversity of values and views. It is easy for a large group to "get carried away" and so we were fortunate to have the services of an experienced and independent facilitator, Elise Herzig, a professional consultant who is currently under contract at McMaster University. She was effective in maintaining order and focus, exploring areas of consensus, identifying issues that may not have consensus but are important and need to be examined later. The result was a list of homework assignments that nobody escaped from. In fact it was clear that all participants are passionate about the CNS and are willing to work hard to make the CNS a success.

Opening with a reception and dinner, attendees and their companions made good use of the "face time" to get to know one another in a social setting and in many cases to connect faces to the names attached to emails that originate from all across Canada. Following dinner we got down to work. Fred Boyd reviewed the history of the Canadian Nuclear Industry from 1944 and how the CNS got to where we are today. [See Fred's article on the 30th Anniversary of the CNS.] The next day, Elise Herzig facilitated the main session.

It is important to recognise the distinction between the current CNS and the Canadian Nuclear Association (CNA). The CNA is a trade organization composed of industry members and is the official advocate of the nuclear industry in Canada. The CNS was originally formed as a technical society and a subsidiary of the CNA (from which it was funded) until it obtained legal separation and was incorporated in name. The CNS is independently funded and is primarily a scientific society composed of individual members who choose to join. Unlike the CNA, the CNS is not an advocacy group.

This is an important distinction for employees of the regulator (CNSC) as they are legally prohibited from membership in the CNA or any other organization that advocates any aspect of the industry that it regulates. CNSC employees are permitted to become members of the CNS and many do so because they benefit, as all members do, from the exchange of scientific papers and discussions. In fact, advocacy was one of the subjects debated in the Special Session. Indeed, the line that separates "advocacy" from "education" gets fuzzy at times given the diversity in membership.

The meeting room was arranged with several round tables and we waddled to the table of our choosing, usually with the people we know best. Ms. Herzig "corrected" our flawed deterministic behaviour and re-arranged us in a more random configuration so that we interacted with more unfamiliar tablemates. This proved to be a wise move since it diversified the opinions that

came forth in discussing the topics before us. To save time, each table was given a different topic and a spokesperson summarised their table discussions for the group as a whole.

In any organisation members have perceptions of what the organisation is about, what it is for, and how it operates. The CNS is no exception and there were many raised eyebrows and lowered jaws as some really deep issues came to light. The CNS views itself as a reliable, objective and dispassionate source of technical and scientific information related to all aspects of the nuclear industry. However, it cannot claim to represent all areas of the nuclear industry if it lacks membership in those areas. Two examples: first, there is a paucity of CNS membership from the Canadian Uranium Mining Industry. Uranium mining is just like any hard-rock mining, and members prefer instead to affiliate with the Canadian Mining Institute. Second, only 20% of the attendees at the recent international conference on CANDU Maintenance were members of the CNS. What about the other 80% who attended this conference? Even more curious is that those 80% did not take advantage of the event registration fee structure where the membership discount is often more than the membership annual fee. The reasons for these anomalies are speculative although many theories were hotly debated.

At the end of the day a very strong consensus emerged about the benefits of being a CNS member. Foremost of all is the opportunity for networking. Members take the opportunity to broaden their knowledge though networking and value the social and professional contact with peers and knowledgeable experts. Members (and non-members) benefit from professional development opportunities by attending conferences and courses organized by the CNS. Communication is an important benefit for members through the Bulletin and Public Outreach programs, to help members keep abreast of happenings in their industry and to provide opportunities to educate the public and politicians and to have some influence on government policy decisions.

I can't list all the benefits because there were too many that were put forth by the participants. Notwithstanding the benefits there are indeed issues that we need to address through further debate. One example is whether the CNS should be proactively advocating the industry, an important issue as discussed above and one that is lacking in unanimous agreement. Another example is whether the CNS is a learned society, given the scientific backgrounds and standing of many members, or instead a broad-based society with a diverse membership including laypersons, students and politicians, for example. Our Branches, based on geography, are not consistently active. Some have regular public seminars, outreach to high schools and education programs while some are not active at all. Our technical divisions may be too focussed on technology development rather than on nuclear operations, for example. These and other issues were the focus of part of the special session and a number of actions were identified.

In summary, the session brought together fifty diverse members of the CNS to articulate and share their ideas about our future direction. While the session was not intended to develop a strategic plan, information about values and perceptions of members were shared. Although some issues lack a clear consensus, there was indeed consensus that the issues are important and need further discussion and resolution. Finally, there was full agreement on the next steps to be taken.

On a personal note, and I think most of those who participated would agree, the most important aspect of the special session was that we had the special session. Inspired by Fred Boyd and supported enthusiastically by President Jim Harvey, past-president Eric Williams and also Jeremy Whitlock and Ben and Denise Rouben, the event was well planned and organized. As a result, we all have a better understanding of our history and our current values, vision and aspirations. And possibly most important, the planning and facilitating effort of Elise Herzig kept us in line to capture and scribe all of the participants' collective thinking which, no doubt, will be translated into a new and solid vision of the CNS and its collective values.

History of the CNS

by Fred Boyd

This year, 2009, marks the 30th anniversary of the creation of the Canadian Nuclear Society. To mark that occasion and to complement the report by Ric Fluke on the "Special Session" of what is called the "Extended Council" of the CNS, following is a note on the origins and history of the Society.

Background

The Canadian nuclear program can be considered as beginning with the creation of the Montreal Laboratory in 1942. A number of nuclear scientists had escaped from Europe to the United Kingdom just before their countries were overrun by the German armies in 1939 and 1940 and joined with UK scientists in research. As conditions in the UK were not hospitable for research an agreement was reached between US President Roosevelt, UK Prime Minister Churchill and Canadian Prime Minister Mackenzie King to have those scientists move to Montreal and be joined by Canadian scientists to work on the design of a heavy water moderated reactor for the production of plutonium to augment the work of the huge Manhattan project in the USA. The first group arrived in the fall of 1942 and set up shop in a new building of the University of Montreal.

Their work led to the basic design of the NRX reactor. The Chalk River site was chosen in 1944 and work begun to establish the Chalk River Nuclear Laboratories including the construction of NRX. A small demonstration reactor, called ZEEP, which was built to test theories, was the first reactor outside the USA to operate when it started up in September 1945.

In the early 1950s studies were undertaken on the possibility of a nuclear power reactor. That resulted in the decision in 1955 to build a small (20 MWe) demonstration nuclear power plant that was called NPD. A joint project was formed of Atomic Energy of Canada Limited, Ontario Hydro, and Canadian General Electric Company. AECL oversaw the project, CGE did the design and oversaw the construction and OH operated the plant, which started operation in 1962.

Creation of CNS

In 1960, with NPD nearing completion and the larger Douglas Point demonstration plant being designed, the companies and organizations involved in the nuclear power program formed the Canadian Nuclear Association (CNA), a trade organization. A few years later the CNA began to hold annual conferences. At its 1973 conference the CNA included some technical papers. Over the next few years that evolved into a "third day" technical program.

Those involved with those "third day" programs and others associated with the burgeoning nuclear power program based on Canadian technology (CANDU) felt there was a need for a Canadian nuclear society. An additional incentive came from fear of inroads by the large American Nuclear Society (ANS).

After months of discussions an agreement was reached with the CNA to create, in 1979, *"The Canadian Nuclear Society – the Technical Society of the Canadian Nuclear Association"*. That (subsidiary) structure was adopted because those founding the CNS felt the need for the financial support of the CNA.

After that formal decision of the CNA Board a "Pro Tem" Council was appointed which in turn named the following "Pro Tem officers: President: George Howey (Ontario Hydro); Vice-President: John Hewitt (University of Toronto) and Secretary-treasurer: Dan Meneley (then Ontario Hydro).

At the first Annual Conference of the Society, held in conjunction with the annual conference of the CNA (in place of the "third day" events) the first elected Council was chosen. Members were: George Howey, President; John Hewitt, Vice-President; Bob James, Secretary – Treasurer; and, as Members-at-Large: Tony Colenbrander, Tom Gellatly, Joe Howieson, Wladimir Paskievici, Phil Ross-Ross, Tom Schur. Jim Weller, General Manager of the CNA served in the same role for the CNS.

A four-sheet typed newsletter was produced and given the name "Bulletin of the Canadian Nuclear Society". Therefore, this is the first issue of Volume 30 of the Bulletin.

Within a year or two branches had been created and divisions

The first elected CNS Council 1980-81

Front L-R: *Wladimir Paskievici; John Hewitt; George Howey; Bob James*

Back *Jim Weller; Tom Schur; Ernie Card; Phil Ross-Ross; Tony Colenbrander*

Absent: *Joe Howieson*

formed. In 1982 the first "Officers' Seminar" was held, bringing together heads of Branches, Divisions with Council to discuss broad aspects of the operation of the society and its future. (In recent years the Officers' Seminar declined in popularity, which was one of the initiating factors for the "Special Session" held in mid January 2009.)

In the spirit of being (or wishing to be) a "Learned Society", in 1987 the CNS launched the "Nuclear Journal of Canada" with reviewed papers. Unfortunately, there was insufficient support for the publication and only four issues were published.

Separation

By the mid 1990s, the Society had become financially sound and some members argued for separation from the CNA. As well as the desire for true independence an additional factor was the prohibition by the Atomic Energy Control Board (predecessor of the Canadian Nuclear Safety Commission) for its staff to join a society that was a subsidiary of a lobby organization.

At the same time the CNA was changing course and welcomed the CNS move.

In 1998, following about two years of discussion, an agreement was reached with the CNA for the CNS to legally separate and incorporate in its own name. The "Letters Patent" include the following statements as the "objects" of the new corporation.

1. to act as a forum for the exchange of information relating to nuclear science and technology;
2. to foster the development and beneficial utilization of nuclear science and technology for peaceful uses;
3. to encourage education in, and knowledge about, nuclear science and technology;
4. to enhance the professional and technical capabilities of those involved in nuclear science and technology in the Canadian context.

A few years later a further "objective" was developed and subsequently included in the "Guidelines" for members of our governing Council but was never formalized. It reads as follows:

> The CNS would also like to be seen as a responsible voice in the public forum on issues related to nuclear science and technology and energy-related issues in general.

The CNS set up its own office in space sublet from the CANDU Owners Group in downtown Toronto and engaged its own office manager. That arrangement is still in effect.

Future

In early 2008 a Task Group recommended some organizational changes including the engagement of an Executive Director. Because of the financial and other implications, that particular recommendation is still being debated.

A "Special Session" of the "Extended Council" was held in mid January 2009 (see separate article). The outcome of that event will be used to prepare a Vision, a Mission Statement, and a set of Goals, that will serve as the basis for a 5-year Strategic Plan. The intent is to have at least the first steps presented to the Annual General Meeting to be held during the 2009 Annual Conference.

CNS president Ben Rouben (2nd from left) and CNA chairman Ernie Card shake hands after the CNA Annual General Meeting, May 4, 1998, at which the CNA passed the necessary motions to open the way for the incorporation of the CNS. With them are Murray Stewart, CNA president (L) and Paul Thompson, CNS president-elect.

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Membership Note

If you have not yet renewed your CNS membership for 2009, it will be cancelled very soon or may have already been cancelled by the time you read this.

In order to maintain your CNS membership in good standing, you can now conveniently and securely renew online and receive your receipt immediately! It is a very fast and convenient process. Just log on to https://www.signupmaster.com/cns-membership and follow the very easy steps.

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

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

Note to CNS student members and past student members: As long as you are a CNS member in good standing in the year that 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

Si vous n'avez pas encore renouvelé votre adhésion à la SNC pour 2009, votre adhésion sera bientôt annulée, ou peut-être sera-t-elle déjà annulée au moment où vous lirez ceci.

Si vous voulez garder votre adhésion à la SNC en bon ordre, vous pouvez maintenant facilement et en toute sécurité renouveler en ligne et recevoir votre reçu immédiatement ! Renouvelez dès maintenant ! C'est vraiment très facile et rapide. Branchez-vous au https://www.signupmaster.com/cns-membership et suivez les instructions.

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

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

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

CNS Council

Call for Nominations

The governing Council of the Canadian Nuclear Society for 2009 – 2010 will be elected at the Annual General Meeting to be held in Calgary, Alberta, Monday, 1 June 2009. (For those unable to attend in person proxies will be available.)

Nominations are now being sought for four executive positions and for Members-at-Large. The President is an automatic succession by the current 1st Vice-President. The following executive positions are open for nominations: 1st Vice-President / President elect; 2nd Vice President; Treasurer; Secretary.

A Nominator and a seconder are required. The Nominee, Nominator and Seconder must all be members-in-good-standing of the Society.

Nominations should be sent to Eric Williams, Past President and Elections Chair, in writing, with signatures of both nominator and seconder, or by separate e-mails from each, preferably by 30 April 2009.

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New Members

We would like to welcome the following new members, who have joined the CNS in the last few months, up to 2009 February 13.

Neman Ali, Bruce Power
Kara Beharry, University of Florida
Stuart Bell, Royal Military College of Canada
Michael Bellicoso, UOIT
Kira Berntson, Bruce Power
Rick Bilkhu, MGA Computer Consulting Ltd.
Gino Bruni, Royal Military College of Canada
Ephraim Bulemela, AECL
Jeffrey Caldwell, AMEC NSS
Serguei Charkov, Kinectrics Inc.
Tristan Charles, UOIT
James E. Cleary, UOIT
Daniel Comeau, NB Power Nuclear PLGS
Tim Crowell, NB Power PLGS
Jason Donev, University of Calgary
Osmani Fernandez, Ministry of Labour
David Foken, TransCanada
Blair Fraser, Babcock & Wilcox Canada Ltd.
Eric Goodman, CTS North America
Harold M. Hergott, Infused Technical Services Inc.
Tony Holden, UOIT
Waleed Jallad, CCBC Community College
John Kennedy, AECL
Monika Kleczek, Royal Military College of Canada
Yevgenia Kravtsova, Kinectrics Inc.
Ashita Kumar, UOIT
Wai Law, UOIT

Nous aimerions accueillir chaudement les nouveaux membres suivants, qui ont fait adhésion à la SNC ces derniers mois, jusqu'au 13 février 2009.

Tom Li, UOIT
Paul Linzender, Promation Engineering Ltd.
Martin Patrick Charles Magill, Mackenzie High School, co-op at AECL
Jeff McDougall, Systemware Innovation Corporation (SWI)
Raj Mistry, McMaster University
Philip Moor, TetraTech EC, Inc.
Brody Mulligan, Algonquin College Pembroke
Martin Nowak, AECL
Peter Papakostantinu, Promation Engineering Ltd.
Markus Piro, Royal Military College of Canada
Benjamin Pollack, Royal Military College of Canada
Mariana Popa, AECL
Kristopher George Probodiak, OPG
Graham B.B. Richards, UOIT
Mathieu Roy, Ecole Polytechnique de Montréal
David Guy Schmidt, AMEC NSS
Mohamed Ezz Shawkat, AMEC NSS
Chad Shew, UOIT
Nataliya Shykinova, SNC-Lavalin Nuclear Inc.
Blair Skinner, Local Government District of Pinawa
Darryl Spector, Promation Engineering Ltd.
Joe B. St-Pierre, AMEC NSS
Sriram Suryanarayan, Kinectrics Inc.
Preston Xiadong Tang, GE Hitachi Nuclear Energy Canada Inc.
Alexandre Trottier, AECL

CNS bursury for WNU Summer Institute

The CNS is offering a bursary of up to $5000 to support a CNS member attending the World Nuclear University 2009 Summer Institute to be held at Christ Church college, University of Oxford, United Kingdom, from 5 July through 14 August.

The bursury will be awarded to a CNS Members in good standing who has applied and been accepted for the 2009 WNU Summer Institute.

Application for this bursary should be sent by email to the CNS Office cns-snc@on.aibn.com by **2009 May 15.**

The application must include:

- information that demonstrates a need for financial support to attend WNU-SI 2009
- a personal resume and summary of work experience.

The applicant must notify the CNS Office by email with a copy of their acceptance for admission to WNU Summer Institute 2009 by 2009 May 23.

CNA creates nuclear high school curriculum

CNS members major contributors

Ed. Note: *The following is based largely on a note prepared by Claudia Lemieux, Director of Communications and Media Relations at the Canadian Nuclear Association.*

Jeremy Whitlock

Close to twenty members of the Canadian Nuclear Society, led by **Jeremy Whitlock** (CNS former president 2003 – 2004), contributed to the creation of a *Nuclear Science Technology High School Curriculum* that the Canadian Nuclear Association released in late in 2008. A workshop on the new curriculum was held on February 25, 2009 in Ottawa, immediately prior to the opening of the 2009 CNA Conference.

The *Education Resource* wbsite is located at the CNA's website, *www.cna.ca*. It was developed over a period of many years drawing upon the expertise of leading nuclear scientists and science educators and with the participation and support of all Science Curriculum Coordinators from provincial and territorial Ministries of Education from across Canada.

The original idea for a *Nuclear Science Curriculum Program* came from Atomic Energy of Canada Limited (AECL). In the mid 1990s AECL hired Clair Ripley, a former science teacher from New Brunswick, to work with science educators in Atlantic Canada to develop curriculum-based information that could be taught in the classroom to explain nuclear energy and atomic theory. Subsequently, New Brunswick Power joined the project.

However, after many years, the project remained unfinished. The CNA, with the support of its industry members, decided it was far too valuable a resource not to be used. Over 2007 and 2008 the CNA, Clair Ripley and a project team of educators, the Canadian Nuclear Society, and scientists from the CNS under the leadership of Jeremy Whitlock, have worked together to complete the project. *(See list of CNS contributors.)*

The CNA expanded the curriculum content to include a broader module on energy and electricity generation and with the help of Ontario Power Generation developed an excellent module on sources of electricity generation with videos explaining how each one works.

The modules, which are also available in French, were developed respecting the Pan Canadian Framework guidelines and other provincial curriculum requirements for teachers in general science, environmental science, biology, physics, chemistry, geography, history, social studies and world issues. The tool is very topical as energy and environmental issues continues to dominate government agendas and public consciousness.

The web-based modules have been designed with multiple strategies to understand the scientific knowledge and issues related to nuclear technology. These include information sheets, instructional media, Videos, animations explaining scientific information, games, electronic publications and other resource materials. Included are more than 50 lesson plans, classroom activities, project descriptions and questions and answer sheets to support teaching and learning about nuclear technologies in the classroom.

The modules focus on eight key areas: Canada's Nuclear History; Atomic Theory; What is Radiation; Biological Effects of Radiation; World Energy Sources; Nuclear Technology at Work; Safety in the Nuclear Industry; and Careers.

They are freely available on a new subset of the CNA website, *www.cna.ca,* entitled *"Education Resources"*

In 2009, the CNA will continue to develop content, lesson plans and promote the Website to ensure that teachers use it across Canada.

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Education and Communication Committee develops teachers' workshop

by Bryan White

*[**Ed. Note:** Bryan is an active member of the CNS Education and Communication Committee]*

The CNS Education and Communication Committee has developed a workshop on ionising radiation for high school science teachers to assist them with preparing their lessons. The notes and the presentation slides are available on the Education page of the CNS website.

The workshop introduces the teachers to the new Nuclear Science and Technology High School Curriculum developed by the Canadian Nuclear Association with major contribution from CNS members *(see separate article)* and provides material to enrich the classes.

This workshop features the use of a sensitive Geiger counter to provide students with personal experience detecting background radiation and monitoring the activity of household items that have Naturally Occurring Radioactive Material (often referenced as NORM) as well as some consumer products that contain man-made radioactive isotopes.

The Science Department Heads of the Renfrew County District School Board provided input to the development of the workshop at a meeting in 2008 October. Doug De La Matter, a retired science teacher from Barry's Bay assisted the ECC in the development of the workshop.

This workshop was presented concurrently at the Science Teachers' Association of Ontario Annual Conference in Toronto and the Alberta Teachers' Association Science Council Annual Conference in Calgary in November 2008. Approximately 30 teachers attended the workshop at each venue.

It was presented again at the Ottawa Carleton District School Board Science Professional Development Day in Bell's Corners on February 13th, 2009 with two sessions of 11 teachers. The workshop includes a hands-on element using 6 demonstration systems.

The Geiger detector selected by the ECC is the RM-80 manufactured by Aware Electronics. A large diameter, thin mica window pancake detector provides background count levels of 40 to 60 counts per minute in most locales. This sensitivity is required to produce results on the time scales appropriate for classroom use. The Geiger interfaces with a personal computer via a serial port. The Windows® software provides audible clicks, plots a real time bar graph, applies alarm thresholds, and logs data for subsequent analysis using a spreadsheet. CNS has purchased six new "netbook" computers (9" screen) for use in the presentations. *(See photo)*

Few schools have the funds to purchase a Geiger. The CNS has donated Geigers to 10 high schools in New Brunswick, Ontario and Alberta – starting with Madawaska Valley District High School in Barry's Bay in about 1995. An initiative is underway to place 30 Geigers in New Brunswick schools in 2009. Another 11 are to be donated to schools in response to requests received following the workshop presentations to date. One was presented at the Ottawa event on February 13, 2009 *(see Branch News)* and additional presentations are planned for 2009. The list of schools that have received Geigers is posted on the website.

Mini computers and gieger detectors for ionizing radiation workshops

Join us in Calgary for our 30th Annual Conference!

"New Nuclear Frontiers"

CNS 30th Annual Conference
and CNS-CNA 33rd Student Conference

30ième Conférence annuelle de la SNC
et 33ième Conférence étudiante SNC-ANC

30 years supporting the
Canadian nuclear community
1979 - 2009

NEW NUCLEAR FRONTIERS
CNS SNC 2009
CALGARY
May 31 - June 3, 2009

May 31st - June 3rd, 2009

TELUS Convention Centre • Fairmont Palliser Hotel
Calgary, Alberta

At this critical time in the evolution of the Canadian nuclear industry, with interest in new-build spreading nationwide, Canada's national nuclear society takes its annual conference to the new frontier itself. Our 30th Annual Conference looks to the next 30 years of nuclear development, with new technologies, processes, and solutions being put in place to meet the challenges of Canadian and global development in a sustainable fashion.

- *2009 W.B. Lewis Lecture/Luncheon*
- *Three plenary sessions + many technical sessions*
- *Western Focus embedded seminar*
- *Western-theme Fun Night*
- *North American Young Generation in Nuclear Professional Workshop*
- *Reception, breaks, exhibits, and other networking opportunities*
- *Guest activities program*

Go to www.cns-snc.ca for registration and other information

Be part of the energy

Branch News

Alberta – Duane Pendergast

A subcommittee has been meeting weekly by teleconference to identify and contact organizations and individuals who could contribute presentations to the W**estern Focus Track** being planned as a sort of seminar within the CNS Annual Conference. A guideline and schedule for preparation and submission of proposals and presentations was prepared and then reviewed by the Conference Chair for consistency with the overall conference. These presentations will be invited and presented in technical information sessions running in parallel with the technical papers. About a dozen proposals for presentations have been submitted and promised to date.

Chalk River – Ragnar Dworschak

Evening Seminars Held:

- January 29: Michel Pettigrew
- February 12: Fred Blackstein, in conjunction with PEO

Evening Seminars Planned:

- March 4: Jim Harvie, CNS President for Annual CNS Chalk River Branch Dinner Meeting
- April: Brent Williams
- June: Richard Nishimura
- August: Simon Ellison

Education and Outreach

Scholarship: In October, communications went out to all the high school in the country. Letters we sent to science heads, principles and guidance. There have been no applications received to date.

Sponsorship of Science Fair and High School Scholarship Award Competitions: We intend to continue our sponsorship and support of the Renfrew County Science Fair. We transformed the essay contest for high school students into a scholarship application with two awards ($1,500, $1,000) and targeting Grade 12 students entering university or community college in the fall of 2009.

The Chalk River Branch donated a Geiger system to Arnprior High School, 12 February 2009. Shown are physics techer Peter Cudmore and Science Department head Karen Dodds.

New Brunswick – Mark McIntyre

On February 17, 2009, Brian Shanks spoke about "Using Technology to Improve Emergency Planning".

Ottawa branch chair Mike Taylor (L) presents a geiger counter to teacher Laurence Taylor.

Ottawa – Mike Taylor

In spite of inclement weather and the Ottawa transport strike, on January 29 a good number of hardy souls turned out for a lunch-time talk by Michel Pettigrew on *" Flow-induced Vibration in Two Phase Flows: Some Interesting Phenomena"*. Michel's talk was interesting and informative. He described new findings from some very fundamental experiments performed by his students at École Polytechnique in Montreal.

Members of the branch manned a CNS stand at the Local Science Teachers' PD Day on February 13. Bryan White presented an *Ionising Radiation Workshop* at the same event. A Geiger counter was presented to one of the science teachers.

Sheridan Park – Adriaan Buijs

In January the Sheridan Park branch had a seminar by Aj Muzumdar on *Large-LOCA Safety Margins*. It was a very exciting seminar with standing room only. The meeting also served as an annual general meeting, during which the activities of 2008 were presented.

The first executive meeting of the new year was held on January 26, 2009, during which a new Sheridan Park Executive Board was appointed:

- Peter Schwanke – President
- Paul Spagnolo – Vice President
- Raj Jain – Secretary
- Olga Jevremovic and Ashlea Colton – Treasurer

(Ogla will be retiring in May, at which time Ashlea will assume full responsibility of the treasurer position)

The next branch seminar has been organized for March 9, 2009. The guest speaker will be James Smith who will be discussing steam generator replacement.

The branch is also in communications with the organizers of the Peel Region Science Fair (April 16th and 17th) to provide judges and awards.

UOIT – Abuzar Fariad

UOIT Open house: The Branch was invited by UOIT to participate in the annual open house February 28th to represent the CNS at the student club fair. We had our own booth and provided information about the CNS in general and the UOIT Branch activities.

Brach Website: The branch website has been moved and renovated at the following URL: http://cns.nuclear.uoit.ca. The site is functional and is being updated.

Branded Golf Shirts: The branch is also planning on retailing branded golf shirts to CNS-UOIT members.

Obituaries

Larry Woodhead

Lawrence Wilfred (Larry) Woodhead, a pioneer of the Canadian nuclear power program, died 28 February 2009, at the age of 80.

Larry was one of the original operating crew that started NPD, Canada's first nuclear power plant, in 1962 and went on to senior management roles in Ontario Hydro.

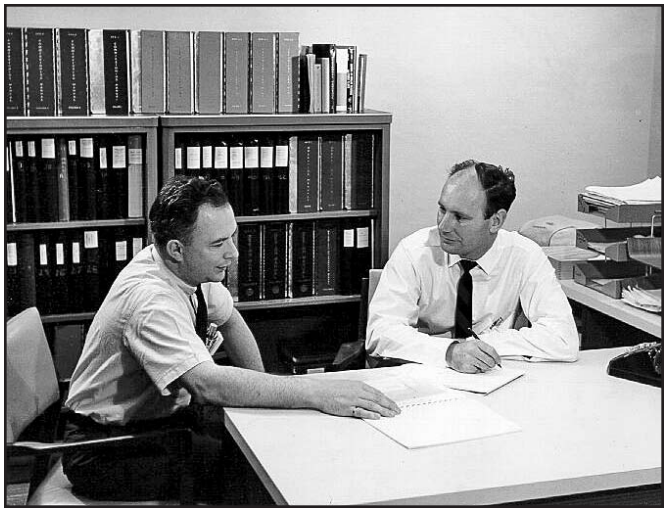
Born in Toronto in 1928 Larry attended the University of Toronto, graduating in electrical engineering in 1951 and named the most outstanding engineering student. After graduation he worked with Westinghouse for one year then joined the Research Division of Ontario Hydro.

In 1956 he was attached to the Civilian Atomic Power Department of Canadian General Electric in Peterborough, Ontario to work on the instrumentation and control design of the Nuclear Power Demonstration (NPD). Transferring to the Ontario Hydro operations staff for the commissioning and operation of NPD he became part of the team that started the plant in 1962. A few years later he became Station Manager of NPD to succeed Lorne McConnell, the first person in that role. Over the next years he also provided operations advice to the designers of the first Pickering station and subsequently was appointed the first Station Manager of what is now Pickering A. In 1974 he was named Director of Nuclear Operations, a position he fulfilled for a number of years. After a number of other senior positions Larry retired from Ontario Hydro in 1992.

He was highly regarded by his staff and others in Ontario Hydro and throughout the Canadian nuclear power program. This was demonstrated by his award of the Ian McRae Award (of the Canadian Nuclear Association) in 1984 for his outstanding contributions to nuclear energy in Canada.

At the memorial service for Larry, March 7, 2009, Lorne McConnell added this personal comment:

"I enjoyed my personal association with Larry at work for some decades and I equally enjoyed my personal friendship with Larry and his family for over half a century. Larry was well known for his sense of humour and his outstanding badminton skills. Even though he performed his work with great dedication, Larry knew how to enjoy life at home and with his friends."



A photo of Larry Woodhead (R) with colleague Sam Horton at NPD circa 1965

Harry Duckworth

Henry Edmison (Harry) Duckworth, scientist, university administrator, and nuclear advisor, died on December 18, 2008 in Winnipeg, at the age of 93, after a short illness.

In 1980, when the Atomic Energy Control Board (predecessor of the Canadian Nuclear Safety Commission) decided to create generic advisory committees, Harry Duckworth, then nearing retirement as President of the University of Winnipeg, agreed to chair the Advisory Committee on Nuclear Safety. He continued in that role until 1990, leading the committee in the production of a number of reports and recommendations on the safety of Canadian nuclear plants.

Born in Brandon in 1915, he attended Wesley College (now part of the University of Winnipeg) and the University of Manitoba (B.Sc. 1936). After teaching at Stonewall and United College, he obtained the Ph.D. in Physics at the University of Chicago (1942). Upon graduation, he was commissioned a Second Lieutenant in the Royal Canadian Corps of Signals.

He began his academic career as a professor of physics at the University of Manitoba in 1945, and continued it at Wesleyan University, in Connecticut, and then at McMaster University. For his scientific achievements he was elected to the Royal Society of Canada in 1954, and later served as its President. He received many awards including Officer of the Order of Canada.

In 1971 he became the second President of the University of Winnipeg, and oversaw a period of rapid development of the University. Following his retirement in 1981, he continued active in academic and community affairs. In 1986 he was elected Chancellor of the University of Manitoba, and served till 1992.

A memorial service was held at St. Andrew's United Church, Oak Street, River Heights, December 27.

Obituaries *continued*

Frank McDonnell

Francis R. (Frank) McDonnell, a long-term employee of Atomic Energy of Canada Limited and a Charter member of the Canadian Nuclear Society died 9 December 2008.

Frank obtained a B.Sc. from the Royal Military College in 1963, a M.Sc. in Nuclear Engineering from the University of Toronto in 1966 and a Ph.D. in Nuclear Engineering from the University of Manchester in 1970 and joined AECL shortly afterwards. Over the next 26 years he filled a number of management positions and was involved in several overseas marketing ventures before retiring in 1997.

He was active in the CNS as chair of the Ottawa Branch and a member of Council.

BOOKS

The Chemistry of Nuclear Fuel Disposal

Donald R. Wiles, Carleton University

ISBN 2-553-01025-7 Polytechnic International Press • www.polymtl.ca/pub • pip@polymtl.ca

Dr. Don Wiles was the senior nuclear chemist on the Scientific Review Group of the Environmental Assessment Review Panel that examined the AECL proposal for disposal of Canada's nuclear fuel waste over the period 1988 – 1998. He studied at McMaster University, the Massachusetts Institute of Technology and the University of Oslo (Norway). He taught radiochemistry for fifty years at Carleton University in Ottawa, from which he formally retired in 1990.

He has stated that this book is addressed at the level of the non-specialist who has at least some familiarity with chemistry. While some chemical and mathematical sections may be difficult, the explanations are mostly at a level accessible to any reader. In the main, the difficult sections can be omitted, at least on a first reading. At the same time, the available knowledge about the Canadian approach to this disposal problem has been fully summarized and explained, so that those around the world who are involved with nuclear fuel waste should find this book useful.

While it is increasingly clear that the technical problems of nuclear fuel waste disposal have largely been surmounted, it is also clear that many of the decision makers are not convinced that this is so. Perhaps more important is the fact that the general public are very apprehensive about the whole issue. Consequently, the real problems are political and social. This book does not take a stand either for or against the use of nuclear power, and attempts to discuss only those aspects of the problem that can be analysed in factual terms.

Illicit Nuclear Trafficking : Collective Experience and the Way Forward

(Proceedings of an international conference , November 2007

ISBN 978-92-0-103408-3 ISSN 0074-1884 • International Atomic Energy Agency, Vienna, Austria

This publication presents the proceedings of the first international conference to specifically address illicit trafficking of nuclear and radioactive material. The principal aims of the conference were to examine the threat and context of such trafficking, to assess the results of activities in place to combat it, and to consider what additional actions are needed. In addition, discussion focussed on how obligations and commitments of binding and non-binding international instruments could be and are being implemented by various States. This volume includes a summary of the conference, the presented papers, the findings of the conference by its president and the conference discussions. A CD with the complete text accompanies the publication.

Nuclear Energy in the 21st Century

Ian Hore-Lacy

ISBN 13:978-0-12-373622-2 • Elsevier Academic Press

Ian Hore-Lacy is the head of communications for the World Nuclear Association in London, England. He wrote this book primarily for attendees of the WNA's World Nuclear University Summer Institute but it can serve as an authorative resource for educators, policy-makers and interested members of the public on the essential elements of electricity generation from nuclear reactors. It contains a foreword from Patrick Moore, co-founder of Greenpeace now head of his own consulting company Greenspirit Strategies Limited based in Vancouver, B.C.

In his introduction the author states that his intention is to get behind the controversies and present facts about energy demand and how it can be met by nuclear power. Nuclear energy has its challenges, he states, but these are misunderstood and misrepresented.

CALENDAR

2009

Apr 5-9 — **6th American Nuclear Society International Topical Meeting on Nuclear Plant Instrumentation, Controls, and Human Machine Interface Technology**
Knoxville, TN, USA
website: http://www.ans.org/meetings

Apr 12-15 — **Advances in Nuclear Fuel Management IV**
Hilton Head Island, SC, USA
website: http://www.anfm2009.org

May 3-7 — **M&C Topical: 2009 International Conference on Advances in Mathematics, Computational Methods, and Reactor Physics**
Saratoga Springs, NY, USA
website: http://www.ans.org/meetings

May 10-14 — **2009 International Congress on Advances in Nuclear Power Plants (ICAPP 09)**
Tokyo, Japan
website: http://www.icapp09.org

May 12-15 — **EIC Climate Change Technology Conference**
McMaster University
Hamilton, Ontario
e-mail: jacksond@mcmaster.ca

May 31-June 2 — **30th Annual CNS Conference & 33rd CNS/CNA Student Conference**
Calgary, Alberta
website: www.cns-snc.ca

June 14-18 — **American Nuclear Society Annual Meeting**
Atlanta, Georgia
website: www.ans.org

July 12-17 — **Twelfth Quadrennial International Conference on Fracture (ICF12)**
Ottawa, Ontario
website: http://www.icf12.com

Aug 9-14 — **SMiRT 20 Conference Int'l Assoc. for Sturctural Mechanics in Reactor Technology**
Espoo, Finland
website: iasmirt.org

Nov. 8-11 — **6th International CANDU Steam Generator Conference**
Toronto, Ontario
website: www.cns-snc.ca

2010

Feb. ?? — **CNA Annual Conference and Tradeshow**
Ottawa
website: www.cna.ca

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

May 30-June 2 — **31st Annual Conference of the Canadian Nuclear Society and 34th CNS/CNA Student Conference**
Montréal, Québec
website: www.cns-snc.ca

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

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

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

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

The 2nd Climate Change Technology Conference (CCTC 2009) will be held in Hamilton, Ontario May 12- 15, 2009.

It is a Canadian / international forum for engineers, scientists, policy advisors, industry and other stakeholders to share and exchange new information and ideas for dealing with climate change and global warming. It also provides an opportunity for participants to keep abreast of emerging techniques and technologies for the mitigation of and adaptation to, the impacts of climate change.

For further informaton and on-line registration go to: www.cctc2009.ca

Twilight

by Jeremy Whitlock

The darkness draws them out. The darkness and the cold.

They crump along in fresh snow or drift in the moonlight, while good people sleep, work, and feed their children, unaware of the hunger about to be satiated.

They are big, they are small. Old and young. Silent. Sensing. Salivating.

They have come before, but always without warning, and always from a different direction, at an unexpected place, to an unexpected vulnerability. The only certainty is that they will come again, when darkness falls and the land chills.

They hunger for knowledge, eaten alive. They drink the warm blood of intelligence and excrete fear, dread, horror. They ravish goodness, render it sinew and bone, and return for more.

The coldest and darkest of months, December, has seen them many times. Deep in the land of ice and snow, far from the warmth of the nearest city, they are known well this time of year. Stockades of moral certitude crumble before them in the snow. Heads roll and are covered in frost by morning. Those assuming command by day will rebuild and retrain, and are never certain to see the next day.

December was not always like this. It was in December over a century ago that useful, happy radioactivity was first extracted from rock by the Curies. Radium glowed through many Decembers, and it was in December four decades later that the by-product uranium revealed its fissioning glory for all to see. Four Decembers after that Fermi's reactor tamed the beast for the first time. Less than a decade passed when the first nuclear electricity lit a dark December in Idaho. Two more Decembers, and Eisenhower's "Atoms for Peace" shone the way forward for a whole planet.

Then a foreboding December in 1952 saw the world's first major reactor accident at Chalk River. Fortunately it was a time when knowledge trumped fear, and what emerged was lightness and learning: a disaster need not ensue from such troubles, people need not be hurt, reactors need not be un-fixable, and an indispensable industry need not be hamstrung.

Half a century later, lightness is a victim and learning an orphan.

A cold December in 2007 saw a non-event at Chalk River descended upon mercilessly. They had come before, but never in such numbers, and never as hungry. Rationality shredded easily before them. Soiled rags hanging from their bodies bespoke respectability in another time, another place, before the downfall of sense and sensitivity: journalists, bureaucrats, politicians, activists. All craved the blood meal of slaughtered science, the better to nurture their young back at the nest. Each fought the other over the carcass, hoping to climb the highest upon it, a symbol of superiority among thieves.

The science reeled, but regrouped.

It is no better prepared, however, for this onslaught a year later, when once more the darkness of December befalls the chilly upper Ottawa Valley. Without warning the snarling horde leaps again from the shadows, taking the heads off the outermost sentries of logic before they know they are there.

The good people awake to the last screams of dying sanity, and the first primal scream of victorious sensationalism. They back to their reason, encircle it, defend the last of their dignity against the encroaching misinterpretation.

Some question aloud how they could deserve this, after protecting the environment to the best of their abilities. The more naive wonder if they were being mistaken for some other entity that wasn't staying three orders of magnitude below its emission limits. The elders know this is no mistake, and hold the line.

And then, suddenly, it seems that a noise or scent in the distance has caught the attention of the menacing siege. Clambering over each other, they race away to ravage some other enticing and unfortunate target.

A truck of human sewage sludge from Ottawa has unwittingly registered radiation as it tried to cross the U.S. border.

Radiation!

The word ignites bloodlust like no other. The brood cackles and howls as it disappears from view. Those spared at Chalk River breathe a sigh of relief, gather their strength, and prepare to rebuild.

Until the next chill wind.

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