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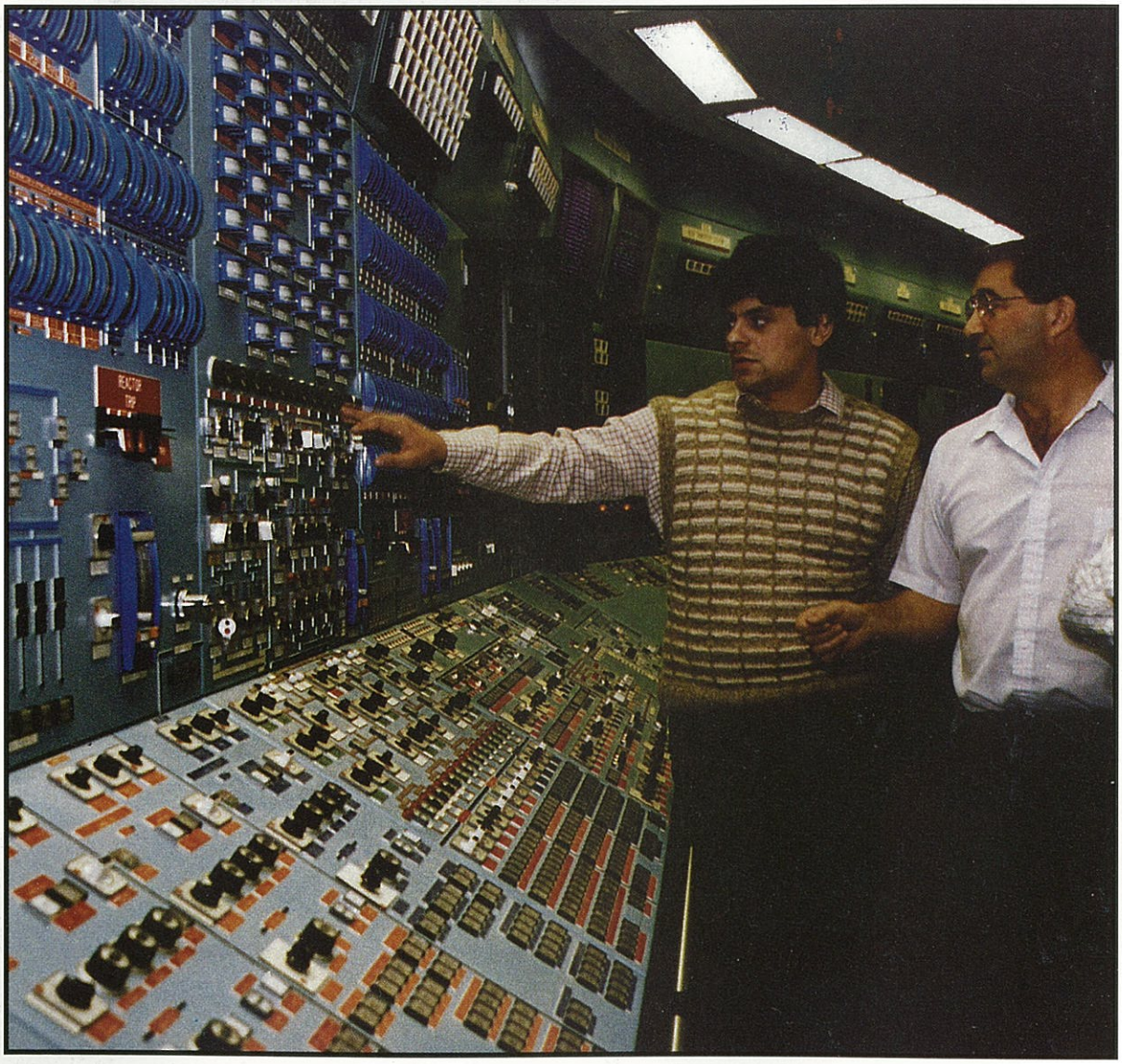

- Remote Manipulator for ITER
- Latest Japanese data and LNT
- Le risque: pensées additionelles
- Conferences, seminar workshops

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Cover Illustration

To symbolize the efforts to regain operational excellence at CANDU nuclear power plants, the cover photograph shows operators training at a simulator, in this case, at Point Lepreau G.S.

(Photo courtesy of NB Power)

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La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ilf peuvent participer à des discussions de nature technique. Pour tous renseignements concerant les inscriptions, veuillez bein entrer en contact avec le bureau de la SNC, les membres du Counseil ou les responsables locaux. La cotisation annuelle est de 60.00$, 35.00$ pour les retaités, et 20.00$ pour les étudiants.

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EDITORIAL

PAST AND PRESENT

The publication of a technical history of AECL's research and development (see article on launch of the new book Canada Enters the Nuclear Age) gives an excuse to look back at some of the achievements over the first half century of our nuclear program. This is a year of significant anniversaries. Probably the most significant one is the 50th anniversary of the start-up of the NRX research reactor, which, at the time and for many years following, was the best engineering test reactor in the world. Then, just a decade later, 40 years ago, the larger, more powerful, NRU reactor began operation. That same year, 1957, saw a pivotal decision, when the NPD design was stopped to be re-directed towards the pressure tube concept that is an essential feature of CANDU.

We need to stop, from time to time, to reflect on what a relatively small group in a country with only a modest population achieved against all odds. Canada is the only country other than the USA that has developed a commercially viable, technically successful, power reactor design, a design which is gaining favour in many countries. And we are the leaders in radioisotopes for medical use.

However, as the opening speakers at the CNA/CNS Annual Conference reminded, there are many challenges facing the industry today. The two highlighted were "competition" and "public opinion". The tide of de-regulation towards open electricity markets is inexorably flooding into this country following the mantra that the "market" will decide everything. Even though the "market" is short-sighted and ignores external factors such as the "green-house" gases produced by burning fossil fuels, it appears inevitable that most of the next generation of electrical generating plants will be burning natural gas, a limited resource with many potential uses. Can nuclear compete in such a market place ? Ontario Hydro's president Allan Kupcis tackled that question and concluded "maybe". Other speakers were less optimistic. Fortunately for the Canadian nuclear industry other countries realize the importance of resources and of the environment and are pursuing the nuclear option. There, according to AECL's Reid Morden, is our near-term future.

In his talk Morden chose to concentrate on the problem of public opinion, acknowledging that regardless how good the technology, regardless of the environmental benefits, if the public does not accept nuclear it will not happen. He urges those in the industry to be pro-active and to speak out when false claims are made, something most individuals and most companies (including Morden's) seem reluctant to do. Such action would undoubtedly be worthwhile but until we show that we can run our nuclear power plants properly the benefits of nuclear energy, even those of nuclear medicine, are going to be hard to sell.

IN THIS ISSUE

Much of this issue is derived from three recent meetings - the first COG / IAEA Workshop on Managing Nuclear Safety at CANDU Plants; the annual COG Safety and Licensing Seminar, and, particularly, the CNA/CNS Annual Conference and the earlier CNA/CNS Student Conference. But, first; there are several very good technical papers to challenge you.

The lead article, **Remote Maintenance in ITER** by **Julian Millard** and **John Blevins,** describes some innovative Canadian engineering to meet the remote handling problems associated with the proposed ITER large fusion machine.

Then, as a further contribution to the on-going controversy about the effects of low level doses of ionizing radiation **Norm Gentner,** in the paper, **Update on Cancer Mortality in A-Bomb Survivors,** succinctly reviews the latest studies of the work that underlies radiation protection standards. Although some may find the terms and concepts unfamiliar, this is almost required reading for those who wish to participate in the "linear / non-linear" debate.

Nous sommes heureux presenter encore un papier en française par **Michel Demers** et **Franck Renault** sur la probleme **Construction d'une Banque de Donneés de Fiabilité.** Si vous comprenez le concept de risque et si vous avez quelque connaissance de française vous le trouverez interessant.

In **CANDU 9 Safety and Licensability,** a paper drawn from one presented at the CNS Annual Conference, **John Webb** and **Victor Snell** provide a concise account of the safety innovations included in the CANDU 9 design and the process arranged for an initial evaluation by the Atomic Energy Control Board.

Turning to the recent meetings, the largest event was the **1997 CNA/CNS Annual Conference** which was held in Toronto, June 8 to 11. There is a report on the conference, and on the **Awards** presented, followed by condensed versions of presentations by three principal speakers: **Allan Kupcis, Reid Morden,** and **Dr. Margeret Maxey.**

These are followed by accounts of the first **COG / IAEA Workshop on Managing Safety in CANDU Plants** which was held in Toronto the beginning of May, and of the 1997 **COG Safety and Licensing Seminar.**

Lisa Lang has provided a comprehensive report on the **1997 CNA/CNS Student Conference** held in Fredericton, NB, last March.

There are a few miscellaneous items of general interest and an extensive section on **CNS News,** reflecting the Annual General Meeting and other activities of the Society over recent months.

Finally, there is some information on recent books of interest and an up-dated calendar of coming events.

We hope that you find at least some of this interesting and invite your comments and submissions.

In the Corridors of Power
(Remote Maintenance in ITER Ducts)

Julian Millard[1] and John Blevins [2]

Abstract

In support of the design and development activities for the International Thermonuclear Experimental Reactor (ITER), Spar Aerospace Limited is designing and building a duct vehicle system to evaluate and mitigate a number of engineering issues associated with the maintenance of the ITER reactor. This consists of a large rail mounted vehicle fully integrated with the associated on board systems required to perform maintenance tasks remotely. This task has been noteworthy in its integration of reactor design with maintenance system design to allow optimisation of both. The system will be tested at the ENEA Brasimone facility in Italy during 1997 allowing both the reactor access corridor/ ducts and remote handling equipment designs to be assessed and finalised. This work is being performed under contract to Canadian Fusion Fuels Technology Project (CFFTP), as part of Canada's contribution to the ITER project.

1.0 Introduction

ITER is a fusion project being designed in a collaborative effort by the USA, Europe, Canada, Japan and Russia. The reactor with its high radiation levels (up to 5E6 rads per hour), inert gas atmosphere (during shutdowns), technical complexity, and massive proportions is a significant maintenance challenge. Figure 1 shows a cross sectional view of the reactor core. Large magnetic fusion reactors rely on divertors to attract and collect plasma impurities to improve and prolong the fusion reaction. The divertor of a large fusion reactor is subject to high heat loads, in the Megawatt range, and plasma impurities or ash . The plasma ash is pumped from the machine through the divertor ducts, which are of complex geometry and have the appearance of large corridors. Four of these corridors or ducts are designated for divertor maintenance activities to permit the servicing of the 60 divertor cassettes located in the base of the tokamak (reactor).

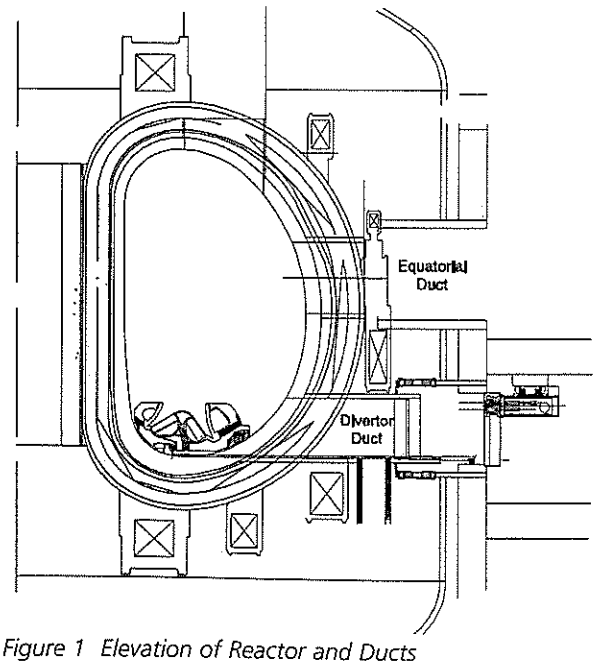

Figure 1 Elevation of Reactor and Ducts

This paper describes the Duct Vehicle System contributed by Canada to the International Thermonuclear Experimental Reactor (ITER) Divertor Test Platform (DTP)[1] located at the ENEA, Brasimone facility in Italy. The system consists of a remotely operated vehicle which, with its on board manipulator and tool pack can unseal and remove the large port plugs, weighing up to 10 tonnes, in the four reactor vacuum vessel maintenance ports to permit the servicing of the divertors. To facilitate this the vehicle deploys its own rail system and performs cutting and welding tasks on the interconnecting divertor cooling piping. A simulated view of the vehicle in the duct is shown in Figure 2. This work is noteworthy as it involves the parallel design and development of the servicing equipment and its worksites in the reactor. The equipment and a related duct mock-up will become part of an extended testing program which is expected to continue until late 1998 to allow elements of the ITER divertor design and layout to be finalised prior to release of the ITER design package in 1998. The divertors will require frequent removal for maintenance due to their high heat loads and service conditions. Hence the critical nature of the DTP program in assuring and demonstrating that the task of remote maintenance of large, heavy, high service components can be done efficiently. Associated with this work for the DTP Spar is performing a related study in support of the L-6 program in Naka, Japan which will model the equatorial ducts and equipment.

2.0 ITER Remote Maintenance

Remote maintenance and component replacement are critical activities for ITER. A rendition of the ITER reactor core and associated magnets is shown in

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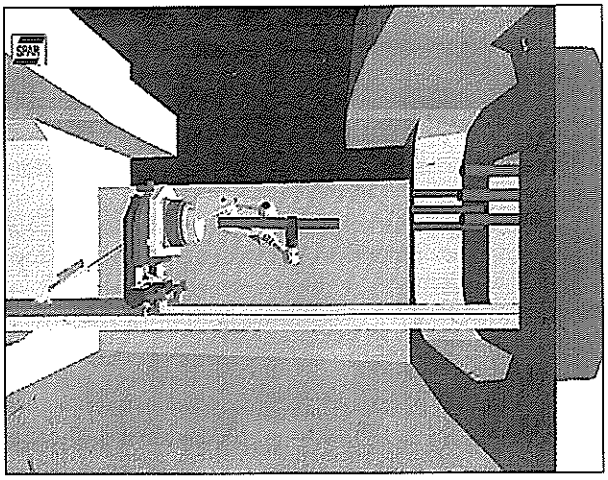

Figure 2 Vehicle in Duct

Figure 3. Access to the core of the torus exists on two levels through a series of radial ducts (corridors). These ducts are about 12 metres long and run from outside the biological shield wall, through the cryostat with it's superconducting magnets and support structures, to port openings in the reactor vacuum vessel. The equatorial level ducts provide access into the centre of the torus vessel while, at a lower level, divertor ducts provide access to the plasma divertors.

Four ducts on each level are designated for shutdown maintenance access. Maintenance of the first wall components inside the reactor vessel is conducted through the equatorial ducts while replacement and servicing of the plasma divertors is performed

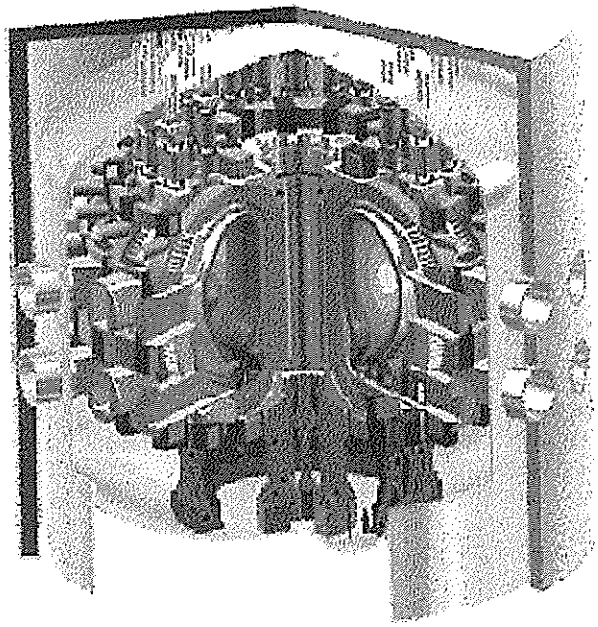

Figure 3 Reactor Cut-Away View

through the divertor ducts. The remaining ducts on each level provide access as required for the maintenance of the specialised equipment contained within them, such as vacuum pumps, and ion and electron cyclotrons (devices to heat the plasma).

Given the significant challenges associated with the ITER maintenance operations two full scale mock-ups are being built to test remote maintenance equipment and systems A mock-up of the equatorial duct and related in core heat transfer blanket handling equipment is being built in Naka, Japan. The divertor level mock-up is being built in Brasimone, Italy. Integration and testing in these mock-ups starts in 1997. Spar, under contract to CFFTP is providing the duct vehicle systems associated with both these mock-ups and is involved in both design of the vehicles and of the duct features with which the vehicle systems interact.

3.0 Project Scope and Organization

The Canadian effort is being managed through the ITER Large R&D program L - 7, which is principally concerned with development of a viable remote handling system for ITER divertor maintenance. In addition it is expected that issues of layout and equipment access will be resolved through the use of the mock up facility.

The Canadian project has been split into 3 phases for both ease of administration, and to allow for flexibility in design, as often occurs in R&D programs of this nature. The three phases are:

- systems design of the duct and equipment,
- design, including prototyping of critical detail parts,
- manufacture and testing of the equipment.

Following the practices developed in our previous ITER work [2] the system was designed using a systems engineering methodology and involved analysis of the duct operations, synthesis of the key requirements, and then design prototyping and optimisation using 3D CAD and kinematic simulation tools in an iterative method. This methodology allowed the

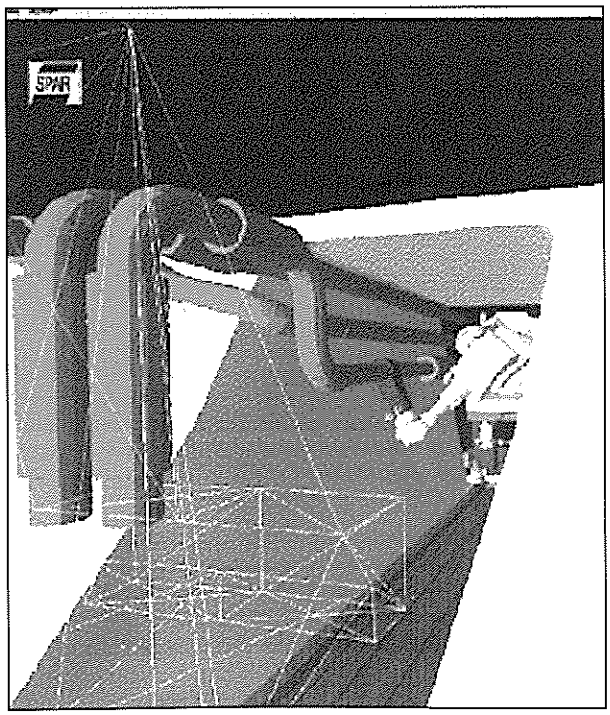

Figure 4 Vehicle Working on Pipes

most critical features of the duct and vehicle design to be finalised relatively quickly thus improving the fidelity and relevance of the duct mock-up and vehicle system prototype. Critical details such as door fastening design could be identified early in the design process and made ready for partial prototyping. Figure 4 illustrates a 3D model of the vehicle and duct produced during this phase.

This process also allows the equipment and its operation to be simplified and resulted in significant reductions in the cutting operations associated with the removal of primary cooling circuit piping.

The design phase involved considerable interaction with the fabricator to minimise the final equipment cost during design evolution. This work included using a robotic arm to develop and test bolt interfaces used in the rail and door design. Figure 5 shows one of the prototype interfaces during testing.

Interfaces of concern to the program were checked on a regular basis with both the equipment manufacturers and the mock-up facility and European project co-ordinators.

4.0 Duct Design

The divertor maintenance ducts, as shown in plan in figure 6, reach from an access cell outside the bioshield in to the divertor at the base of the reactor core. The ducts incorporate a number of obstacles

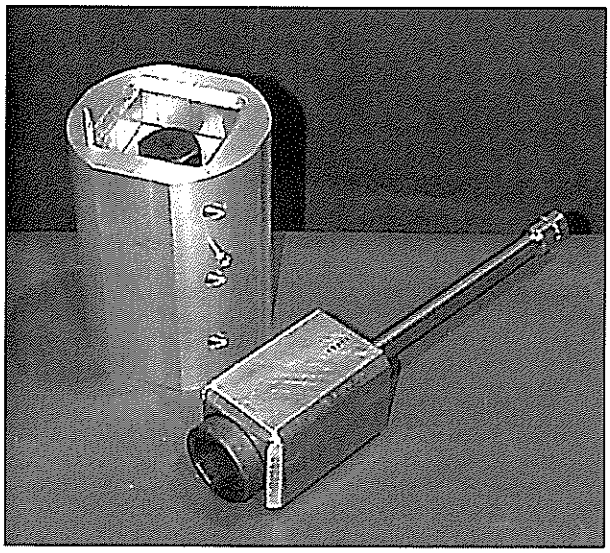

Figure 5 Prototype Bolt Interface

which must be removed or bridged to allow divertor removal and replacement. They include a large concrete shield door in the bioshield wall (which is pulled out of the way), a steel closure plate in the cryostat wall, a bellows section which accommodates the differential movements between the cryostat and the torus, a vacuum closure plate in the main torus vacuum vessel, and a final section containing diagnostic equipment and lined with services including cooling pipes and diagnostic cabling. The equatorial ducts are similar except for the fact that they are sealed at the boundary of the reactor plasma chamber (vacuum vessel) with a plug consisting of heat transfer blanket modules. The design of the duct internals involved resolving a number of conflicting design constraints including:

- the space limitations established by the superconducting magnet systems surrounding the reactor;
- the need to optimise the space for plasma diagnostic elements for reactor control and performance testing;
- the need to provide enough access space for remote equipment along with features to allow their efficient use;
- the need to maintain the separation of the different vacuum and gas atmospheres, and containment for radiation.
- A number of novel design solutions resulted,

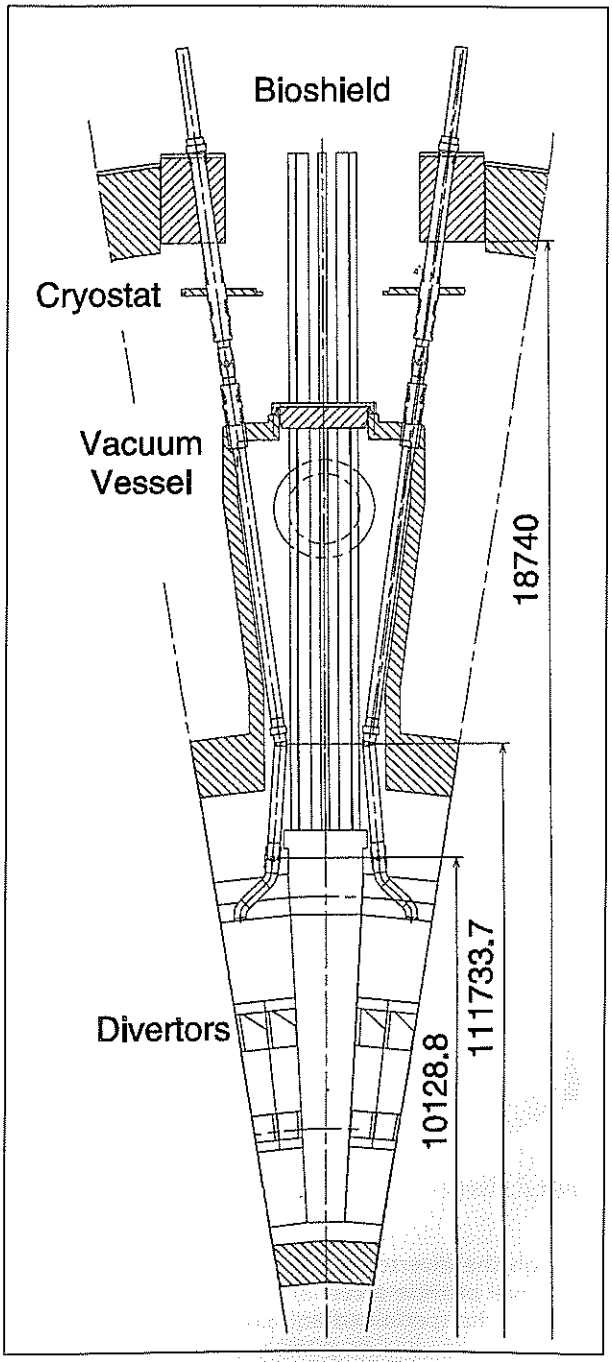

Figure 6 Plan View of Divertor Duct

including the rerouting of a number of cooling pipes and services to both improve access and maintenance.

5.0 Equipment Operation

The divertor handling vehicle system was designed to perform the following operations in DTP;

- Undo the approximately 50 mounting bolts on the cryostat closure plate
- Remove the 1 tonne cryostat closure plate
- Deploy a 1.3 metre long section of radial rail
- Undo the approximately 50 mounting bolts for the vacuum vessel closure plate
- Cut the 7.5 metres of welded seal on the vacuum vessel closure plate
- Remove the 8 tonne vacuum vessel closure plate
- Deploy a second section of radial rail

As part of the conceptual design work these operations were modelled on IGRIPtm, a commercially available 3D kinematic simulation package. The simulations were performed in order to ensure sufficient access space, check manipulator reach, optimise the vehicle layout, including positioning of cameras, and fully define and optimise the proposed tasks.

6.0 Equipment Description

The remote handling equipment supplied by Canada to the DTP consists of three subsystems, a duct vehicle system, a bore tool deployer, and a control equipment suite.

6.1 Duct Vehicle System

The duct vehicle system is comprised of four elements: a vehicle, a manipulator, a rail handler, and some tools.

The duct vehicle (see Figure 7) is a remotely operated, rail-mounted, electric powered truck with an 8 tonne lift, designed to pitch a payload forward 2 degrees and backwards 47 degrees. The lift mechanism incorporates a door-latch actuator and a self aligning pick-up interface. The door-latch actuator engages and disengages a door latch mechanism. The pick-up interface allows the vehicle to engage either a duct door, a manipulator arm, or a rail adapter (used for lifting sections of removable rail). The door-latch actuator also serves as the mating drive mechanism connector for supplying power, video and data signals for the manipulator. The pitch axis serves two functions, aligning the payload with the duct structure, and pitching the payload back so as to clear obstacles as the system moves back down the duct. A vacuum cleaning system is mounted on the vehicle to enable cutting debris to be collected during operations and is interfaced through the manipulator adapter. The vehicle also contains a small air pump and a small water pump to support the manipulator and it's tools. Four pan-tilt unit/camera/lens systems are mounted on the front of the vehicle - two are located on the top of the moveable lift section while the others are fixed low down on the vehicle frame. Flood lights for general scene viewing and spot lights for detailed viewing are also mounted near the cameras. An omnidirectional microphone will be located at the front of the vehicle to pick up sounds which may assist an operator in performing tasks.

The manipulator is permanently fixed to an adapter plate system, which also contains tool holders. The manipulator mounted on it's adapter is loaded onto the vehicle using an overhead crane and then remotely locked in place using the vehicle door-latch actuator. The manipulator is a modified electric industrial robot. Figure 8 shows a view of that robot in a tool performance test setup. It has 6 degrees of freedom, a 45 kg payload capacity at full acceleration and

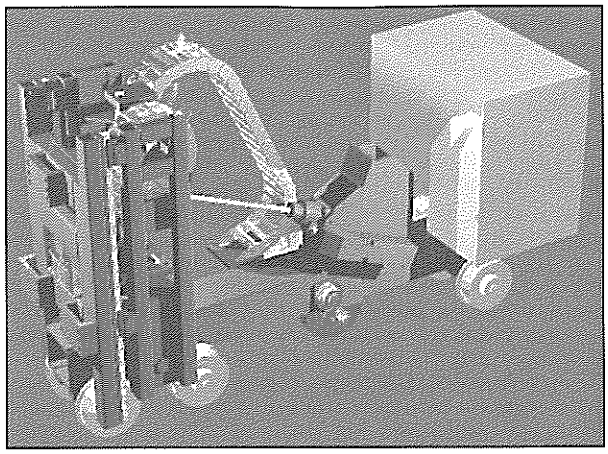

Figure 7 Duct Vehicle

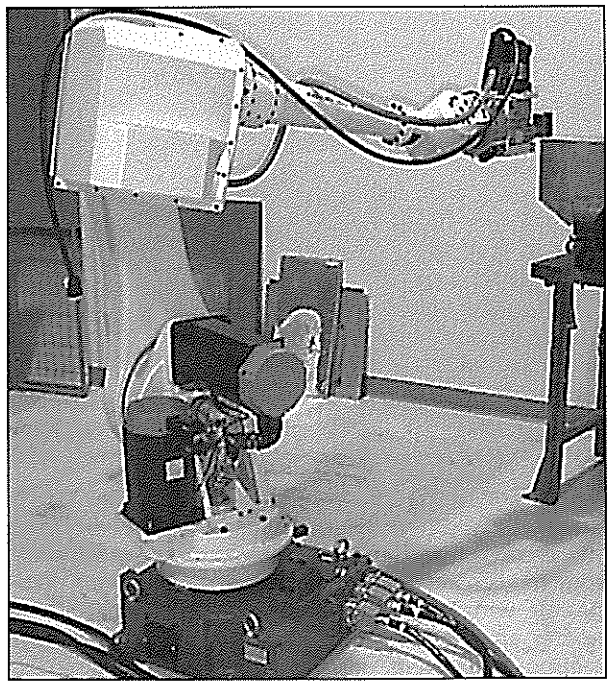

Figure 8 Cutting Tool Test

velocity and a repeatability of less than 0.5 mm.

The robot has a spherical operating envelope approximately 1.7 m in diameter (as circumscribed by its wrist), and includes the capability to reach behind itself . A force/moment sensor mounted on the robot wrist provides feedback to an operator to facilitate alignment of tools with the worksite. A tool exchange plate mounted after the force/moment sensor enables

tools to be exchanged on the manipulator and provides power, data, video, gas and coolant services to the tools. The tool holders are passive mechanical structures. Space on the adapter plate for four tools is currently provided within the workspace of the robot. These tools are, a medium capacity bolting tool, a high capacity bolting tool, a vacuum seal cutting tool, and a gripping tool.

The medium capacity bolt tool is an electric torque

Figure 9 Medium Capacity Bolting Tool

tool designed to remove and install captive M24 bolts with an associated torque reaction interface on the rail sections and the doors. An automotive assembly tool and controller were modified to make them compatible with the robot tool exchange plate, its tool holder and the bolt interface. The bolt tool and its mating parts were designed to; avoid transmitting torque through the robot, keep the bolt captive, and improve operator awareness of the bolt/ unbolt operations through use of visual cues. Tool to bolt head alignment occurs automatically when the tool drive rotation begins. Figure 9 shows the bolt tool during testing.

Three competing versions of the tool to bolt interface have been evaluated resulting in the selection of the square version. This interface sacrificed some space but gave by far the best visual and tactile cues during use.

The high capacity bolt tool is an off the shelf, high pressure hydraulic tool. It is expected to be commissioned during the later stages of testing on the DTP.

The seal cutting tool is a modified off the shelf nibbler. This tool was selected after tests using a variety of other cutters including grinders and millers. The gripper tool is designed to move sections of pipe within the divertor duct. The prototype tool has a parallel jaw gripper with a gripper travel from 75 mm (3") to 180 mm (7"). Development work on this tool has been deferred until the equipment test phase on the DTP.

The rail adapter, a passive frame, allows the vehicle lift mechanism to remove and replace sections of the radial rail. It is capable of supporting a 1.3 metre section of rail weighing 1.5 tonnes. The lower face of the removable rail section has alignment features to locate and center the rail section, and 4 bolts to fasten the rail to the mockup. The top of the removable rail section has two eyes which mate with the rail adapter.

6.2 Bore Tooling System

The Bore Tooling System is designed to remotely cut the divertor cooling pipes from access positions outside the bioshield. Bore tooling developed in a collaborative effort between Canada and France is being upgraded by both parties to suit L-7 project requirements. Canada is supplying a higher capacity tool deployment system. The bore tool deployer is based on STEM technology [3]. Figure 10 shows a typical BiSTEM unit. It will be driven by an independent control system supplied by France. The STEM is mounted at the open end of a pipe and the bore tools are inserted into the pipe and positioned by the STEM to a prescribed position to perform either cut or weld operations. Initially the divertor cooling system pipe configurations were curved requiring modifications to be made to the STEM. The current reference is a straight pipe design which enables the use of a conventional single layer 79 mm (3.12") diameter BiSTEM to deploy the bore tools. Due to improvements in the clearances around the piping in the duct the number of cuts required on the cooling circuit pipes has been reduced from two to one.

6.3 Control Equipment

The control equipment is situated in a location remote from the mockup area in keeping with ITER environmental requirements. The control equipment is located in two separate cabinets and an operator console. The use of less expensive commercially available equipment resulted in the need to use two cabinet locations to accommodate the limitations in the allowable lengths of the data buses. The first cabinet houses the commercial off-the-shelf control equipment for the manipulator, bolt tool and force/moment sensor and is situated at the end of the rails, (at a position equivalent to the outside of the ITER bioshield). The second cabinet is located about 30m from the first cabinet, adjacent to the ENEA control room and it houses custom control equipment for system power conditioning, system control, duct vehicle control and other tooling control. The operator console is to be positioned in a viewing gallery above the DTP.

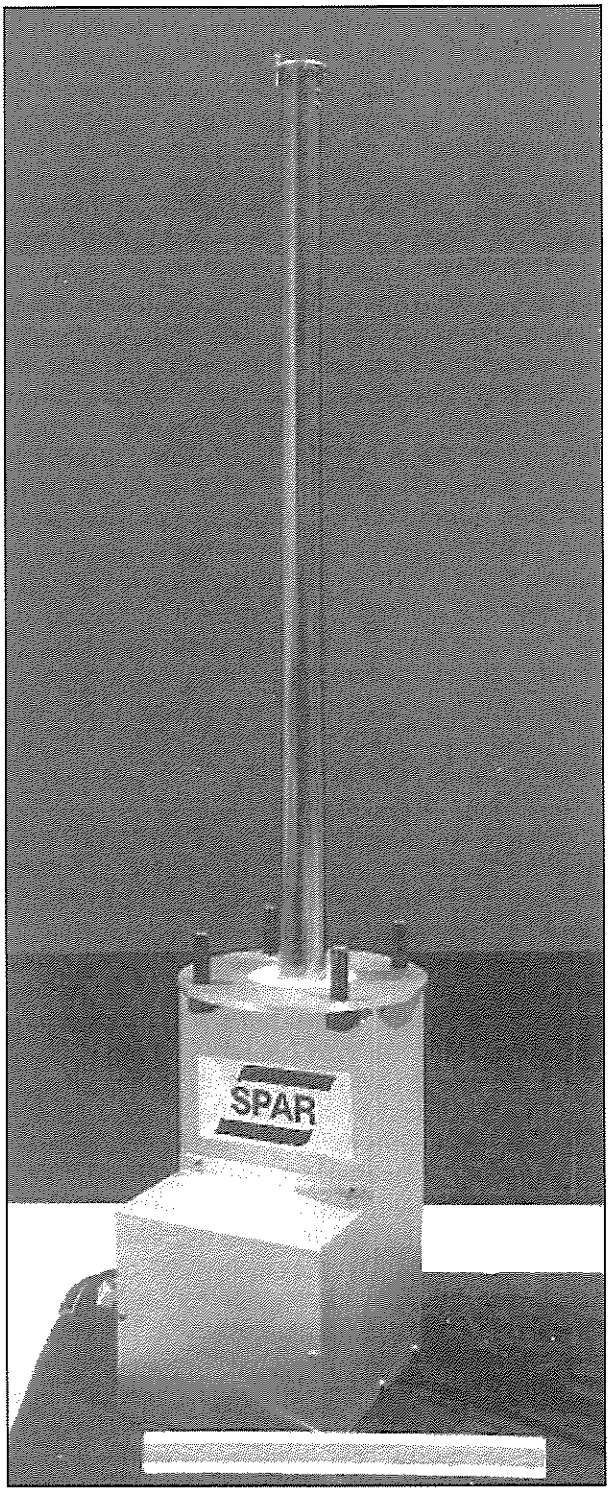

Figure 10 Typical BiSTEM Unit

The operator interface consists of a graphical user interface, translational and a rotational rate hand controllers, a hardware switch and power status panel, a speaker, video monitors, and controllers for the pan/tilt units, cameras and lenses. The hardware switch panel contains an emergency stop in addition to power enable/disable switches for the vehicle, manipulator and tools. Except for video system control, the hand controllers provide features for operating the duct vehicle system without the need to use a keyboard. These features include rate limiting selection, tool start/stop and a mini-joystick and forefinger trigger for selecting a feature on the graphical user interface. ENEA will provide the video equipment controllers and video display monitors.

7.0 Interaction of equipment and duct

In order to perform this work efficiently and fully assess the interactions between the maintenance system and the duct a number of modelling and testing activities were performed. During the design phase several critical tasks were identified. These were the layout of the cooling pipes, the design of the door, its seals and fastening system, and the design of a deployable rail system. The tasks was structured to allow simple kinematic interactions to be studied using computer models. The dynamic aspects of the interactions were studied under test using a combination of partial and full scale models. The use of less expensive modelling tools simplified both the duct and vehicle design and improved the delivery schedule. Simplification of the testing programs reduced the risk of delay and allowed us to concentrate on those items which could not be verified with computer modelling and subsystem prototype testing. As a result the DTP test program can focus on problems in the design of the remote equipment associated with the duct, and improve the level of fidelity in the final ITER EDA design. The DTP test program will include investigation of, the rail design, door seal design, and the interaction of the main maintenance systems.

8.0 Conclusions

Parallel and cooperative design of the duct and the duct maintenance equipment significantly enhanced the system design. Using 3D CAD tools and kinematic simulations allowed the work to progress efficiently despite communications and interface challenges which arose from the need to work closely with design teams in the USA, Europe and Japan. The resulting system has met or exceeded its design requirements and will play a pivotal role in the testing at DTP.

Acknowledgments

The authors would like to thank their colleagues and collaborators, at Spar, CFFTP, ITER, NEL, NET and ENEA. who helped make this work possible.

IGRIP is the trademark of Deneb Robotics.

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Update on Cancer Mortality in the A-Bomb Survivors

by Norman Gentner

Ed. Note: *As most readers of the CNS Bulletin are aware, there is a growing debate about the "linear no threshold (LNT) model which underlies the recommendations of the International Commission on Radiological Protection (ICRP) and, thereby, the radiation protection regulations in most countries. The major evidence supporting LNT comes from the study of the survivors of the atomic bomb attacks on Hiroshima and Nagasaki at the end of world War II.*

Dr. Norman E. Gentner, a senior scientist with the Health and environmental Sciences Division of Atomic Energy of Canada Limited at Chalk River and a member of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) has followed these studies closely. In the following paper, which is a condensed (by the author) version of one he presented at the 1997 CNS Annual Conference, he provides a concise review of the recent update of the study of the bomb survivors and offers comment on its applicability to the LNT debate.

The *Radiation Effects Research Foundation* (RERF) in Hiroshima has recently released an updated study of cancer mortality in its Life Span Study (LSS) cohort of survivors of the atomic bombings at Hiroshima and Nagasaki (1). (The LSS is believed to contain about one-half of the total number of survivors who were within 2.5 km of the hypocentre.) The update has considerably more statistical power than earlier studies because there have been five more years of follow-up (1986-1990 inclusive) and because 10,536 survivors for whom the 1986 dose estimates (DS86) recently became available, have been added. Together these add about 550,000 person-years of follow-up compared to the previous report, which covered mortality to the end of 1985. Moreover, about 25% of the excess of observed over expected solid cancer deaths have occurred in these last five years of follow-up.

The cohort now has 86,572 subjects for whom doses have been estimated (a prerequisite for epidemiological studies). There are 50,113 members with estimated doses greater than 0.005 sievert; the mean dose for this subset is 0.20 Sv. These were mostly persons within about 2.5 km of the bombings in Hiroshima or Nagasaki, and who still lived in the cities in 1950. The remainder of the LSS represents 36,459 people with doses estimated to be <0.005 Sv. These constitute a comparison group, mostly from survivors within 2.5-10 km of the hypocentre, for whom radiation doses were low or negligible. They were age- and sex-matched to the "exposed" subset.

This communication summarizes and analyzes salient findings of the RERF update, and discusses these in the context of the current debate as to whether risk from the types of exposures encountered occupationally may be linear with dose or not.

Numbers of Excess Cancers

Radiation-risk estimates in the LSS are based on a relatively small number of extra cancers. In the overall LSS cohort ("zero" plus "exposed"), there has been a total of 7827 observed deaths from cancer versus 7406 expected, for a total of 421 excess cancer deaths during the period 1950-1990. For solid cancers, there were 7578 observed deaths versus 7244 expected (difference = 334), and from leukemia there were 249 observed deaths versus 162 expected (difference = 87). (The "expected" numbers are the estimates of the expected number of cancer deaths for the cohort had there been no radiation exposure.)

One useful way to explain the radiation-related contribution is the **"attributable risk"**. The attributable risk for solid tumors in the LSS, that is, the fraction of the total cancer deaths which can be ascribed to radiation among those with a non-zero dose, is 0.08 (i.e., 8%).

Most of the excess leukemia has already occurred, mostly within the first fifteen years following exposure. For solid cancers the excess absolute risk has continued to increase, in proportion to the natural, age-specific risk. It is the projected total number of excess cancers estimated to occur which is the basis for radiation risk coefficients.

Of the cohort, 56% overall were still alive at the end of the period covered by this analysis. Survival ranges from 94% for those aged 0-9 ATB [at time of bomb] to 16% for those 40-49 ATB (1% for those 50+ ATB). There is thus little uncertainty about projecting the lifetime risk of those exposed

as adults, since most have died. There remains, however, some uncertainty about how best to project the lifetime risk of those exposed as children,. Different risk projection models give lifetime excess risk estimates which range from essentially the same as for persons exposed at age 30, to a risk which is 1.8-times as large. Continued follow-up of the LSS is important to decrease the uncertainty remaining with respect to this group.

This number of "421 excess cancer deaths" should not be taken as representing the total number of cancer deaths to date in the "population of A-bomb survivors", because the LSS cohort includes only about half of the "exposed" group, and of these, only the 80% or so for whom doses have been assigned. A proper estimate of the total cancer deaths to 1990 attributable to the detonations would therefore be approximately 1050.

Radiation-Induced Fatal Cancers

Both linear and non-linear models were tested for "goodness of fit". Models which were linear in dose raised to a coefficient *k* were used to provide this assessment. The authors reported that models with $k<1$ generally provided a worse fit than a linear ($k = 1$) model. Put another way, there was no statistically significant non-linearity in the range 0-3 Sv for excess solid cancers (above 3 Sv, the slope decreased somewhat, which may reflect cell-killing). In view of this, risk results over the whole range of exposures were quoted in terms of risk per Sv for induced solid cancers. The excess absolute risk (EAR) per sievert for solid cancers, for persons exposed at age 30, was estimated as 0.10 for males [10% per Sv] and 0.14 [14% per Sv] for females. (Risks for someone exposed at age 50 were about one-third of these values.)

For leukemia, the excess lifetime risk at 1 Sv was about 0.015 for males and 0.008 for females, for exposure at either 10 or 30 years of age (for exposure at age 50, the leukemia risk was about two-thirds this). The reason why the leukemia risks are quoted at 1 Sv as opposed to "per Sv" is that a linear- quadratic equation, as opposed to a linear equation, best fitted the leukemia data. The non-linear fit is such that for leukemia, the risks estimated at 0.1 Sv are about one-twentieth those at 1 Sv; in other words, one-tenth the dose gives a two-fold lower risk than expected by strict proportionality to the risk at 1 Sv.

These risk coefficients, it should be remembered, hold only in a statistical sense, for the "average" of a population, and don't necessarily apply to any particular individual.

No Evidence for a Threshold

The LSS authors state that the new data do not provide any evidence to support a contention that there is a threshold below which no excess risk exists. The uncertainty in the lower dose categories has decreased since the last analysis (which covered up to 1985). If there is any departure at all from linearity in the present data, it is in the direction of apparent risk being greater in the very low dose categories. The estimated values for risk per Sv in the three lowest dose categories are greater than the value obtained using the entire 0-3 Sv range of data (Table 1). However, there are shortcomings in the quality of the mortality data at low doses which indicate that this apparent supra-linearity may be an artifact. The values of excess relative risk (ERR) per Sv in the lowest dose categories are just barely statistically significant, and even this may simply be due to a greater likelihood of cancer actually being recorded on the death certificate as a cause of death for survivors from near the blasts compared to those distant..

Table 1
Estimated values for ERR per sievert in the lowest dose categories (1)

Dose category (Sv)	ERR per Sv (–standard error)
0.005-0.02	2.6 – 2.1
0.02-0.05	1.6 – 0.90
0.05-0.10	0.60 – 0.40
0.10-0.20	0.43 – 0.25
0.20-0.50	0.38 – 0.13
(0-3 Sv; overall range)	**(0.37)**

Risk in Hiroshima Continues to be 'Greater'

Higher estimated radiation risks persist for Hiroshima compared to Nagasaki. The city differences have in fact increased since the last report. The idea that the cities could be brought into line by increasing the neutron component at Hiroshima has received considerable attention (2). Based on neutron activation analyses of mineral and metal samples, correction factors have been estimated for the neutron component of DS86 dose; these factors depend on slant range, and have values of about 0.75 at 650m, 1.0 at 750m, 2.0 at 1000m and 10 at 1600m (2). But the RERF authors do not think that revision of the dose estimates for neutrons would greatly alter radiation risk coefficients, as the most important data in the LSS dose-response analysis come from the range of doses received by persons located in the slant range between 1000-1200m ATB. For such persons, DS86 estimates the neutron component of their dose as about 1_%, and even if adjusted upwards by 2-3-fold, the net effect at most would be only about 15% decrease in the risk estimates for solid cancer in Hiroshima.

Lowest Dose at Which There is a Statistically Significant Risk?

Earlier analyses of the LSS cohort indicated statistically significant excess cancer mortality only for doses above 200 mSv (3); this was the lower bound of the dose category for which the rate in the "exposed" population was significantly higher than in the "control" population.. In this updated analysis, the "lowest dose at which there is a statistically significant excess risk" was established in a different way than before, as the authors felt that the former approach of testing for significance in arbitrary dose categories was inappropriate. Their approach was to determine the minimum dose dm for which a statistically significant dose response existed when analysis was restricted to the range [0, dm]. This dm was 0.05 Sv (50 mSv). In other words, a statistically significant trend of radiation effect is seen when data inside the interval from zero dose to 50 mSv was considered on its own. The authors state that "The range d < 0.05 [Sv] for a significant effect is substantially less than has been reported previously." Although it follows conventionally from a direct trend test, this conclusion ought to be taken with a grain of salt. It reflects the same data which led to the particular ERR/Sv values in Table 1, and is subject therefore to the same shortcomings: specifically, it may be influenced considerably by the greater bias in exposed compared to control group (4) in actually having cancer marked down as "cause of death" on the death certificate. In pointing out this caution, the RERF authors noted that the apparent "supra-linearity" diminished considerably when cancer incidence was used in the same sort of assessment, probably because tumor registry incidence data is supported by more accurate diagnostic criteria than is the case for certification of cancer as a cause of death.

Comments

The total risk at 1 Sv—solid cancers plus radiogenic leukemias—sums up to be 0.115 (11.5%) for males and 0.148 (14.8%) for females, or an average of about 0.13 (13%) for the two sexes (for exposure at age 30), weighted equally.

The difference in EAR between men and women misses being statistically significant, but not by much. While there was a considerable difference in excess relative risk (ERR) per Sv in this study (the value for women being about twice that for men), this was offset considerably by their lower natural rate of cancer mortality: in Japan, for age 30, the lifetime background risk of dying from cancer is presently about 21% for women and about 29% for men. As EAR is obtained by multiplying ERR by the natural background rates, the ERR men/women ratio of 2:1 telescopes to an EAR ratio of 1.4:1. It is noteworthy that the major single contributor to the higher EAR for women was stomach cancer and not the sex-and site-specific cancers like those of the breast, uterus and ovary. In Japan stomach cancer is quite common; in North America, rates are markedly lower. The contribution to EAR of radiogenic stomach cancer would decrease the sex difference in a North American population compared to Japan. On the other hand, in Canada the natural rates of fatal cancer are approximately the same for males and females; this would tend to make the sex-related difference greater if the ERR factors were applied.

The true coefficients for probability of fatal cancer in the LSS are probably higher than the weighted 0.13/Sv derived above. Two types of errors are recognized which indicate these values may underestimate the risk. "Misclassification errors" are one type. An appreciable proportion of cancer deaths are known in general to be misclassified as non-cancer deaths on death certificates; a much smaller proportion of non-cancer deaths are misclassified as cancer deaths. The misclassification rates were found to be 20% and 3%, respectively, which is greater than the approximately 1:3 ratio of deaths from cancer versus "all other causes" (4). A correction for misclassification errors would increase the EAR by a factor of about 1.16, and the values reported here do not have this correction applied. The second type of errors relate to dosimetry. The coefficient of variation in individual dose estimates is about 35%. This imprecision is not randomness (which statistical methods allow for) but rather is systematic bias, in the direction that results in underestimation of risk. If allowances were made for these systematic dose errors, it has been estimated elsewhere that the cancer risk estimates would increase by a further factor of about 1.1 (5). Applying these two types of corrections to the new RERF coefficients discussed here yield a radiation risk coefficient, weighted for both sexes, approaching 0.17 [17%] per Sv. (Or, from a different perspective, these factors would more than offset future possible allowance for increased neutron dose in the Hiroshima subset of the LSS.) These data of course relate to high doses delivered at high dose rate.

The corresponding lifetime fatality probability coefficient used by the International Commission on Radiological Protection, for the whole population for the sum of all malignancies, is 0.10/Sv for high doses and dose rates (6). (For a reference population of both sexes and of working age, it is 0.08/Sv.) The risk coefficients from the present RERF study are somewhat higher than this, but the ICRP judgment incorporates other study populations, various risk projection models, and five national populations in its transfer models (6).

Linear vs Non-Linear Thinking

These high dose, high dose rate, coefficients are not used without adjustment. The ICRP does recognize the lesser effectiveness of radiation delivered at low doses and/or dose rates in inducing stochastic effects. An **allowance for non-linearity,** in the context of radiation protection, is made by the ICRP in its extrapolation (for low LET radiation) from data at high doses and dose rates to estimate the nominal probability of effects at low doses and low dose rates (6). The "instrument" that recognizes this non-linearity is a two-fold reduction applied to the probability coefficients derived from direct observations at high doses and dose rates; this "factor of 2" is called the Dose and Dose Rate Effectiveness Factor, or DDREF (6). It is already included in all of the ICRP's probability coefficients for all equivalent doses resulting from absorbed doses <0.2 Gy, or from even higher absorbed doses if the dose rate is <0.1 Gy per hour. (For leukemia, the two-fold lower initial rate reported here for the "best fit" of the data, to a linear-quadratic equation, amounts to the same thing, although it is not a DDREF as such). The "low dose and low dose rate" probability coefficients thus become 0.05/Sv for the whole population and 0.04/Sv for a working age population (6). The Commission recognizes that there is a wide spread in apparent DDREF factors from various observations, and holds that the selected value of 2 "is somewhat arbitrary and may be conservative".

The question for radiation protection is whether a flat value of two suffices for most practical purposes. The explicit recognition of non-linearity by incorporating a single value of DDREF, of course, still leads to a "form of linearity" for the low dose and low dose rate situation, albeit with a different slope than for high doses and dose rates. The fact is that the high dose/high dose rate situation is fundamentally different – both in terms of patterns of energy deposition and in mechanisms of radiocarcinogenesis – from the low dose/low dose rate situation which exists in the vast majority of persons exposed occupationally. Cancer is many diseases. Not all will be affected in the same way by radiation, or show the same dose response, or respond to dose protraction in the same way.

While there is a reasonably proven body of data to support the conclusion that radiation at high doses and high dose rates produces dose-proportional excess fatal cancers, it does not automatically follow that this applies for occupational exposure. However, if linearity does not apply at low doses and low dose rates, the challenge is to prove this.

The problem in assessing the risk of low level exposures is how and where to obtain data of sufficiently high quality. It should not be expected that each and every type of cancer will always show a radiation-related risk; the issue is whether enough do so that we cannot regard risk as short-circuiting to zero below some dose rate or finite value of dose. Data certainly do exist which argue that the risk may be appreciably lower in particular situations for certain individual sites of cancer. The risk of lung cancer in tuberculosis patients given highly fractionated exposures from fluoroscopic examinations (7) is clearly inconsistent with expectation using the ICRP-recommended coefficient. But this is only for one target organ. What is needed is similar high quality and statistically powerful data from a variety of such situations.

The issue for radiation protection therefore becomes whether there exists any consonant set of data that suggests that the coefficient for low doses and/or low dose rates over-estimates risk. Results from studying groups of nuclear industry workers tend to be somewhat equivocal. A standardized mortality ratio of less than one for a worker population, by itself, proves nothing other than that the risk is not huge. And where risk has been assessed as a function of dose categories, a wide range of risk values exist, with estimates which range from no risk at all (or even a protective effect) to point estimates much higher than the ICRP probability estimate. The majority have confidence intervals so wide that they prove or disprove very little.

This conclusion holds even for consolidated studies organized for the purpose of garnering increased statistical power. For example, the International Agency for Research on Cancer (*IARC*) study of cancer mortality rates among nuclear industry workers in the UK, USA and Canada (8) was a high-visibility attempt to address the question of risk of induced cancer in persons occupationally exposed to ionizing radiation. This study involved data on 95,673 workers (85% of whom were men) employed for six months or more and who had been monitored for external exposure to ionizing radiation. The excess relative risk for leukemia (excluding chronic lymphocytic leukemia, known not to be radiogenic) was 2.18 per Sv, with 90% confidence intervals (CI) of 0.1 and 5.7. This is the result most widely touted, as it is the only statistically significant result. When the data for males in the A-bomb survivor cohort was analyzed in a strictly comparable way, the resultant value of ERR/Sv was 3.67 (90% CI: 2.0, 6.5). The IARC risk coefficient thus implied an effective DDREF value of 1.7 for leukemias. The apparent congruity of these results with the ICRP estimate and DDREF value led to the assertion that "These estimates are the most comprehensive and direct estimates of cancer risk associated with low dose protracted exposures obtained to date", and "Overall, the results of this study do not suggest

that the current radiation risk estimates for cancer at low levels of exposure are appreciably in error". Yet the leukemia conclusion rested on a total of only 119 fatal cases, and what gave statistical significance was the 6 cases (compared to 2.3 expected) in the highest dose category (> 400 mSv).

This IARC result is not a sufficiently consonant result, by my criteria. This is because, for "all cancers excluding leukemia", the ERR was -0.07 per Sv (90% CI: -0.4, 0.3). Unfortunately, although this provided no evidence for an increased risk in these workers, the result also lacked sufficient statistical power to prove that the risk for solid cancers was in any whit lower than the estimate from the A-bomb survivor data (an ERR/Sv of 0.24, calculated in a corresponding manner); worse, the IARC result was unable even to exclude that the risk might be higher.

In evaluating the risk that may attach to occupational exposure, it is time to stop looking at these low levels, and time to look to higher dose scenarios with greater statistical power. We need not look as low in dose as we have, since radiobiological studies indicate that the dose rate range where lower dose rate makes an impact is still well above dose rates encountered occupationally. If we wish to make a case that low dose risks are currently over-estimated, neither rhetoric nor selected cases suffice as argument. It is incumbent on us to supply the data. Neither the public nor the regulators would – or should – accept less than credible and defensible proof.

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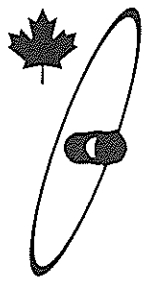

Construction d'une banque de données de fiabilité : Définition et rationalisation des besoins

by Michel Demers[1], Franck Hénault[2]

Résumé

L'objet de ce document est de présenter les quatre phases principales d'une méthodologie qui permet de définir et de rationaliser les besoins en matière de banque de données :

- Phase A : Identification des besoins,
- Phase B : Examen de l'environnement existant,
- Phase C : Réalisation d'une étude de pré-faisabilité technico-économique,
- Phase D : Rédaction d'une synthèse sur les buts, les concepts techniques retenus, etc.

Il propose, pour décrire chacune des phases précédentes, une succession d'activités jugées essentielles à son accomplissement. Il justifie la réalisation de ces activités au travers d'observations diverses qui explicitent leur intérêt.

Enfin, sur la base de l'expérience d'implantation d'une banque de données de fiabilité à la centrale nucléaire Gentilly-2, ce document offre une série d'enseignements pour l'application de cette méthodologie.

1 Introduction

Bon nombre d'activités industrielles de cette fin de XXè siècle requièrent l'utilisation de banques de données de retour d'expérience. L'exploitation d'une centrale nucléaire de production électrique, non seulement de ne pas pouvoir déroger à cette tendance, impose aux hommes qui en sont en charge d'être pionnier dans ce domaine.

Mais l'implantation et l'exploitation de banques de données de retour d'expérience coûtent cher. Elles doivent être absolument sources d'enseignements sur des phénomènes spécifiques ciblés. Elles ne doivent pas uniquement servir à la simple accumulation d'informations. Aussi, pour éviter cet écueil fatal à la pérennité de cet outil de connaissance, il est indispensable de définir avec la plus grande précision possible, les besoins auxquels il devra satisfaire.

C'est le but poursuivi par l'étape préliminaire de définition et de rationalisation des besoins dans le cadre de l'implantation de toute banque de données dans le milieu nucléaire, comme dans le reste de l'industrie.

Les sections suivantes explicitent les quatre phases principales d'une méthodologie qui permet de définir et de rationaliser les besoins en matière de banque de données. Par ailleurs, elles proposent des enseignements utiles lors de sa mise en pratique.

Avertissements : La définition et la rationalisation des besoins, étape au combien importante de l'implantation d'une banque de données ne recouvre pourtant pas tous les points reliés à cette activité. Par conséquent, bien des aspects qui ne sont pas abordés dans les sections suivantes de ce document doivent faire l'objet de réflexions. Par exemple, l'acquisition d'un outil informatique approprié doit être soumis à un processus de sélection particulier, à part entière.

Au-delà, il est important d'attirer l'attention du lecteur sur le fait que tous les détails de la méthodologie de définition et de rationalisation des besoins, n'ont pas été traités ici. Par exemple, certaines des activités de cette méthodologie sont appelées à être exécutées de façon itérative. Le "niveau d'exhaustivité" de leur réalisation lors de chacune des itérations n'a pas été évoqué. Les profils idoines, tant au niveau de la structure organisationnelle, que des acteurs de chacune des phases de cette méthodologie, ne font pas non plus l'objet de développements.

2 Définition et rationalisation des besoins

1 Identifier les besoins (Phase A) - Définition

Généralement, c'est l'exigence d'obtenir des indicateurs{3} d'aide à la décision (pré-requis), résultats du traitement de données brutes, qui justifie de colliger ces dernières dans une banque.

(1) Hydro-Québec, Centrale nucléaire Gentilly-2
(2) Électricité de France

Ceci constitue l'identification d'un besoin, en quelque sorte "origine", autour duquel il faut colliger l'ensemble des besoins connexes pouvant exister.

Pour cela, les activités suivantes sont requises :

1 Identification des intervenants potentiels autour de la banque de données

Il s'agit de répertorier de la façon la plus exhaustive possible l'ensemble des clients, des fournisseurs et même des supports techniques, pour qui l'exploitation de la banque de données modifiera peu ou prou les rôles et responsabilités.

2 Examen de leurs besoins respectifs et exigences particulières

Pour chacun des intervenants potentiels recensés, il s'agit d'identifier et d'analyser les besoins en relation directe et/ou transverse avec le (ou les) besoin identifié comme "origine". Les exigences particulières (exigences techniques d'obtention d'indicateurs, exigences réglementaires de traçabilité de telle ou telle donnée, etc.) de chacun d'entre eux doivent être aussi examinés.

3 Évaluation approximative des bénéfices (note 1) escomptés

Il est indispensable pour les activités ultérieures de cette phase A, d'acquérir une idée approximative des bénéfices potentiels de la satisfaction de chacun des besoins inventoriés. Le milieu industriel, sous la coercition du pouvoir économique, ne peut pas se permettre de s'engager sur des voies uniquement exploratoires.

4 Établissement d'un langage commun à tous les intervenants

Il est fréquent que le nombre d'intervenants répertoriés, d'origines diverses, soit important. À ce titre, il est indispensable d'établir un langage commun à tous. Ce langage doit favoriser l'établissement d'un dialogue entre les différents types d'intervenants (clients, fournisseurs, supports techniques).

5 Maîtrise des liens entre les différents intervenants potentiels

Les besoins de chacun doivent être ciblés puis regroupés de façon à gagner en cohérence par rapport aux réalités du terrain. Des besoins peuvent être complémentaires ou antagonistes, il s'agit de clarifier les demandes. Ceci permet d'assurer, en partie au moins, que l'ensemble des intervenants sera satisfait lors de l'exploitation de la banque de données.

Par exemple, il pourra être demandé à un utilisateur d'offrir un service dépassant la simple satisfaction de ses exigences propres, ceci, afin de pouvoir répondre plus facilement aux besoins exprimés par un autre utilisateur.

6 Rationalisation et priorisation des besoins

De facto, lors de cette priorisation des besoins, les réflexions doivent intégrer les exigences particulières répertoriées, ainsi que les résultats de l'évaluation approximative des bénéfices escomptés de la satisfaction de chacun d'entre eux.

Produit obtenu : À la fin de cette phase, il est nécessaire de figer les résultats des réflexions portées sur les besoins exprimés de chacun des intervenants identifié. Par exemple, les grilles clients-produits peuvent être un moyen de colliger et d'entériner ces résultats pour clore cette phase, afin d'éviter toute remise en question des options retenues à ce niveau.

Cette clarification des besoins permet par ailleurs d'apprécier l'envergure des efforts qui seront à consacrer en vue de l'implantation de la banque de données.

Remarque : À cette phase de la méthodologie, aucune contrainte technique ni financière ne doit faire l'objet d'une prise en compte dans l'expression des besoins. Par contre, il est important de mentionner à tous les intervenants que ces contraintes interviendront lors de l'étude de pré-faisabilité technico-économique et, éventuellement, pourraient restreindre davantage le nombre de besoins effectivement retenus.

Il faut accepter suite à la priorisation des besoins, la possibilité que le besoin identifié initialement comme "origine", ne soit pas retenu comme étant le plus prioritaire.

Note 1 Par le terme bénéfices, il ne faut pas seulement entendre bénéfices financiers. Les bénéfices escomptés de l'exploitation d'une banque de données sont de deux ordres :

- des bénéfices non quantifiables facilement selon un aspect financier (par exemple, amélioration du niveau de sûreté, de la pertinence des études, de l'organisation, etc.),
- des bénéfices quantifiables financièrement pour un retour à court et moyen terme (par exemple, réduction des coûts de maintenance, de l'indisponibilité de l'outil de production, des coûts de gestion des pièces de rechange, etc.).

Il est à remarquer que ces derniers sont des résultats non indépendants des premiers.

1 Examiner l'environnement existant (Phase B)

Comme pour l'implantation de tout nouvel outil, il est nécessaire de recenser l'ensemble des contraintes du milieu d'accueil. Dans le domaine des banques de données, cette phase requiert à

(3) Ces indicateurs permettent de ramener une somme d'informations d'origines diverses, toujours grandissante, à une dimension compréhensible par l'utilisateur. Ils offrent des renseignements sur un ou des phénomènes spécifiques ciblés. Souvent, le besoin se traduit par la nécessité d'obtention d'indicateurs entièrement nouveaux, ou d'une précision accrue pour des indicateurs déjà existants.

minima la réalisation des activités suivantes :

B1. Examen des sources de données

- Revoir exhaustivement les différentes sources de retour d'expérience disponibles dans l'entreprise, des plus officielles (les systèmes de gestion de l'entretien), aux plus officieuses (le calepin du contremaître).
- Cibler les sources de retour d'expérience pertinentes.
- Identifier et analyser les lacunes existantes de chacune des sources de retour d'expérience pertinentes en vue d'y pallier.

B1. Examen des processus (intervenants, tâches) de collecte, d'analyse et d'assurance de la qualité des données, existants à l'interne

- Identifier et définir les processus existants autour des sources de retour d'expérience pertinentes, de ceux qui relèvent d'un encadrement officiel à ceux qui sont hérités de la pratique courante.
- Identifier les lacunes des processus existants de collecte, d'analyse et d'assurance de la qualité des données.
- Analyser, voire élaborer, des solutions préliminaires pour la correction des lacunes identifiées (élaboration de pistes de solution).

Produit obtenu : À la fin de cette phase{4}, il est nécessaire de rédiger un état des lieux et de formuler des conclusions objectives sur les lacunes identifiées tant au niveau des sources de données qu'à celui des processus associés.

Remarque : À cette phase, il n'est aucunement question d'identifier les correctifs spécifiques à engager. Ce sont les résultats de l'étude de préfaisabilité technico-économique qui dicteront à la fois les lacunes à corriger, parmi toutes celles relevées, ainsi que le type de correctif à leur appliquer.

1 Réaliser une étude de pré-faisabilité technico économique (Phase C) - Rationalisation

Cette phase doit permettre, à partir de la priorisation des besoins (phase A) et de l'état des lieux (phase B), d'élaborer les solutions techniques les plus appropriées et de hiérarchiser les couples, [Réponses techniques - Coûts de réalisation]. C'est finalement à partir des résultats de cette hiérarchisation et de l'estimation que l'on peut faire des bénéfices envisagés de chacune des solutions retenues, que l'on obtiendra un éventail des réponses techniques les plus pertinentes.

1 Hiérarchisation des couples [Réponses techniques - Coûts de réalisation]

C1. Estimation et hiérarchisation des moyens à mettre en oeuvre pour corriger les lacunes identifiées **à la phase B au niveau des sources de données et des processus de collecte, d'analyse et d'assurance de la qualité des données.**

- **Identifier exhaustivement, pour chacune des lacunes relevées, les moyens potentiels utiles pour leur correction (note 2).**
- **Pondérer, pour chacune des lacunes relevées, les forces et faiblesses technologiques ainsi que les coûts de mise en oeuvre des moyens identifiés.**
- **Évaluer approximativement les bénéfices escomptés de la correction de chacune des lacunes répertoriées en corrélation avec les résultats de la priorisation des besoins (phase A).**
- **Hiérarchiser les moyens identifiés sur la base de leur pondération ainsi que des résultats de l'évaluation des bénéfices escomptés.**

C1. Estimation et hiérarchisation des options technologiques existantes **présentant le plus d'affinités avec les besoins envisagés, issus de la phase A, ainsi que les coûts associés.**

- Identifier exhaustivement, pour chacun des besoins identifiés, les options technologiques (type de banque de données, administration des données, processus de vérification de la qualité des données, etc.) potentielles aptes à répondre aux contraintes imposées.
- Pondérer, pour chacun des besoins identifiés, les forces et faiblesses technologiques, y compris les coûts de mise en oeuvre, quant à la réponse offerte par chacune des options technologiques identifiées.
- Évaluer approximativement les bénéfices escomptés de chacune des options technologiques répertoriées en corrélation avec les résultats de la priorisation des besoins (phase A).
- Hiérarchiser les options technologiques identifiées sur la base de leur pondération ainsi que des résultats de l'évaluation des bénéfices escomptés.

C1. Création d'une matrice d'association, Besoins / [Sources de données - Processus] **de collecte, d'analyse et d'assurance de la qualité. Cette activité est nécessaire pour assurer l'évaluation la plus juste possible des efforts (coûts, ressources, moyens, etc.) à consacrer pour rencontrer chacun des besoins.**

(4) Il peut se révéler utile de recourir pour cette phase à une expertise reconnue en matière d'évaluation des méthodes de gestion du retour d'expérience. En effet, le client n'est pas toujours à même d'identifier certaines des lacunes latentes de l'environnement dans lequel il évolue.

- Le produit attendu de cette première étape est une liste hiérarchique des couples [Réponses techniques - coûts de réalisation].

1 Estimation des bénéfices (note 1) reliés à la rencontre des besoins exprimés

Il s'agit de déterminer les avantages et les désavantages envisagés reliés à l'implantation de chacune des réponses techniques de l'étape précédente et aussi d'évaluer les conséquences de l'exclusion de chacune d'entre elles. Il est à noter que cette estimation des bénéfices s'avère particulièrement difficile. Nul ne peut être parfaitement clairvoyant sur l'étendue des bénéfices liés à telle ou telle solution.

En aucun cas, une banque de données ne peut, à elle seule, être la réponse à tous les problèmes d'exploitation vécus par une entreprise. Ce sont les analyses qui sont réalisées à partir des données de la banque qui permettent d'obtenir des résultats tangibles. C'est le taux d'utilisation des données de la banque et les résultats des traitements effectués qui sont l'assurance de sa pérennité. Il faut donc juger du couple occurrence d'utilisation/importance et qualité des services rendus pour statuer de la rentabilité d'une banque de données. Ce jugement, porté a priori lors de l'étude de pré-faisabilité technico-économique, devra ensuite être reposé régulièrement au cours de l'exploitation de la banque de données.

1 Le produit attendu de cette deuxième étape est une liste hiérarchique des couples [Réponses techniques - Bénéfices escomptés].

1 Détermination de l'éventail des réponses techniques les plus pertinentes

On ne conserve que les réponses techniques dont les ratios Bénéfices / Coûts sont les plus élevés.

2 Le produit attendu de cette dernière étape est l'éventail des réponses techniques obtenu selon les critères explicités précédemment.

Produit obtenu : Le produit de cette troisième phase est un document présentant les conclusions de l'étude de pré-faisabilité technico-économique. Il devra être explicite, à minima, quant aux choix retenus, aux lacunes à corriger, aux coûts estimés, aux moyens à mettre en oeuvre, etc.

Par ailleurs, il est important d'exposer à tous les intervenants les conclusions de cette étude et d'expliquer pourquoi tel ou tel besoin ne sera pas satisfait, au moins dans les premiers temps de l'exploitation de la banque de données. Il est important que les conclusions de l'étude fassent foi. Néanmoins, la sous-évaluation d'un aspect spécifique aux conséquences non négligeables peut arriver. Il ne faut donc pas s'interdire toute adaptation des conclusions de l'étude de pré-faisabilité technico-économique : il en est encore temps.

Remarque : La réalisation de cette phase requiert l'assistance d'une expertise reconnue dans le domaine de la gestion du retour d'expérience, des banques de données, etc. En effet, l'analyse des coûts et des bénéfices envisagés ne peut être, à ce niveau, qu'essentiellement basée sur l'avis d'experts, qui sont les seuls à pouvoir effectuer des prévisions réalistes sur ces aspects.

Par ailleurs, lors de la réalisation de cette étape, il est essentiel de prendre en compte, autant que possible, les évolutions pressenties tant au niveau des besoins, qu'au niveau de l'environnement ou des outils. Seuls des experts vont pouvoir élaborer une approche intégrant ces évolutions.

Enfin, il faut mentionner que le recours à une expertise procure un poids supplémentaire aux conclusions de l'étude, ce qui ne sera pas négligeable lors des présentations aux divers intervenants.

Note 2 Selon le type de lacunes identifiées, au niveau des sources comme au niveau des processus, la correction s'effectuera :

1. soit directement à la source (mise en place d'un processus d'amélioration de la qualité, modifications matérielles et/ou informatiques de la source, etc.),
2. soit par une organisation spécifique de la banque de données qui permette de pallier aux lacunes identifiées.

La solution #1 est à privilégier, comme le démontre l'expérience acquise. En effet, cette façon de procéder corrige à la source les lacunes observées et évite des adaptations de la banque de données qui ne lui apporteraient pas de plus-value. Des adaptations multiples de la banque de données s'avèrent souvent antagonistes et, en pratique, difficiles à réaliser.

Est-il besoin de rappeler que la crédibilité des résultats (qualité des indicateurs) dépend directement de la qualité des informations qui transitent dans la banque de données et ainsi, d'insister sur le fait que tous les efforts doivent être engagés pour obtenir la meilleure qualité.

1 Présenter les buts, les concepts techniques retenus, leurs justifications et finalement les objectifs à atteindre (Phase D)

Cette étape constitue une synthèse des réflexions menées précédemment. Cette synthèse doit se traduire par la rédaction d'un document qui devra donc aborder, au minimum, les points suivants :

1 définition des buts poursuivis par la création d'une banque de données, à partir de :

1.1. l'analyse des besoins des utilisateurs envisagés (identification du type de

traitement souhaité à partir des données de la banque),

- *il faut être conscient que seul le résultat des traitements effectués à partir des données de la banque, rentabilise cette dernière.*

1.2. l'étude de pré-faisabilité technico-économique des besoins exprimés,

1.3. l'identification des options retenues.

Lors de cette définition des buts, il est nécessaire d'être réaliste :

- quant à la réponse efficace que peut fournir une banque de données par rapport aux besoins exprimés,
- quant aux efforts soutenus que nécessite cet investissement important,
- quant aux bénéfices, souvent difficilement mesurables à court terme, qui peuvent en être retirés.

– définition des concepts retenus (type de banque de données, structure organisationnelle, cheminement de l'information, etc.), qui sont directement dépendants des buts poursuivis.

– identification des justifications entourant la création de la banque de données (exigence réglementaire, justification économique et/ou organisationnelle, suivi de l'évolution technologique, etc.),

– définition des objectifs à atteindre en vue de l'implantation de la banque de données. Selon les buts définis et les concepts retenus, la suite logique des objectifs à atteindre peut varier. Néanmoins, l'expérience permet d'identifier certains objectifs importants, voire incontournables, à savoir :

a) rédaction ou modification des procédures existantes,
b) correction des anomalies décelées sur les sources d'information primaires,
c) rodage du circuit de l'information corrigé (peut être intégré à une étude pilote),
d) rédaction d'un devis technique,
e) revue et étude comparative des produits existants (le choix final doit aussi prendre en compte les évolutions technologiques pressenties),
f) implantation physique de la banque de données (outils informatiques),
g) etc.

Remarque : Certains des objectifs précédents, tels que ceux mentionnés aux points a, b et c, sont soumis à des mécanismes itératifs en vue de leurs atteintes. Ce sont aussi des objectifs qui demandent des dépenses importantes de moyens et de temps et, à ce titre, ne doivent pas être négligés.

Certains des objectifs à établir font appel à des processus à part entière, dont tous les critères ne sont pas abordés lors de la définition et la rationalisation des besoins.

1. estimation des bénéfices liés à l'exploitation de la banque de données (cohérence et traçabilité accrue des informations liées à l'exploitation de l'installation, amélioration de la disponibilité de l'outil de production, fourniture d'un outil d'aide à la décision supplémentaire, etc.).

Note 3 Il existe une forte interrelation entre les points 1 et 2. En effet, pour se fixer des buts réalistes, il est indispensable d'avoir une idée relativement précise des solutions techniques applicables (concepts retenus). En contrepartie, avant de définir les concepts à retenir, il est important d'identifier précisément ce que l'on recherche (les buts) avant de constituer une banque de données de retour d'expérience. Certains des buts peuvent se révéler contradictoires.

Remarque : Il est indispensable que ce document ait fait l'objet d'un consensus auprès de tous les intervenants avant de penser à l'implantation physique de la banque de données. L'implantation d'une banque de données souffre d'une incompréhension endémique, due à un certain nombre d'exigences (longs efforts continus, nécessitant des investissements importants, dont les bénéfices sont difficilement mesurables à court terme), difficiles à satisfaire. La rédaction d'un tel document de référence, dans la première étape du projet d'implantation de la banque de données, permet de répondre aux questions régulières des gestionnaires qui ne manqueront pas et ainsi de les rassurer.

1 Enseignements

Comme dans toute autre activité structurée et organisée, il n'existe pas pour la méthodologie présentée, de recette assurant la réussite de son application.

Toutefois, sur la base du retour d'expérience qui fait suite à l'implantation de la banque de données de fiabilité des équipements de la centrale nucléaire Gentilly-2, quelques enseignements génériques peuvent être énoncés.

<u>Au niveau technique</u>

- Tout d'abord, il est primordial qu'une importance toute particulière (en moyens, ressources et temps) soit accordée dès le début du projet d'implantation d'une banque de données à cette étape préliminaire de définition et de rationalisation des besoins. C'est un risque considérable que de négliger cette activité.

Les orientations retenues de la rationalisation des besoins permettront, entre autres :

- d'apprécier avec une meilleure précision l'en-

vergure des efforts qui seront à consacrer en vue de la correction des lacunes du milieu existant,

- d'anticiper sur les efforts à consentir pour l'adaptation des outils présents sur le marché,
- de pouvoir effectuer un choix éclairé de l'outil informatique le plus approprié possible, dans le contexte existant,
- etc.

De la crédibilité des résultats obtenus à cette préliminaire dépend souvent le succès final de l'implantation et de l'exploitation d'une banque de données.

- La méthodologie exposée s'articule autour du concept central de priorisation récurrente des besoins (hiérarchisations successives selon des critères sélectifs). Tout d'abord, il est nécessaire de prioriser les besoins exprimés selon leurs bénéfices potentiels (respect d'exigences, gains attendus). Puis sur cette base, il faut hiérarchiser chacun d'entre eux selon des critères restrictifs de faisabilité technico-économique.

  Même si les différentes phases de la méthodologie ont été explicitées de façon à diminuer toutes les ambiguïtés possibles, sa mise en pratique ne relève pas d'un processus parfaitement figé et rectiligne.

  En effet, certaines des phases de cette méthodologie sont appelées à être exécutées de façon itérative. Le nombre, l'enchaînement et la finesse de réalisation de ces itérations pourront varier selon la structure d'accueil (compétences existantes dans le domaine), l'ampleur du projet d'implantation (moyens mis en oeuvre), etc.
- Il est à noter que l'établissement d'un langage commun à tous les intervenants, est une activité atypique dans cette méthodologie, qui ne doit pas être négligée. La recherche d'une suppression de toutes les ambiguïtés possibles dans le dialogue facilite souvent la réalisation de chacune des activités exposées et/ou gratifie les résultats obtenus à chacune d'entre elles, d'une qualité supérieure.

  De cette communication réussie dépend aussi la pérennité de la future banque de données.

Au niveau organisationnel

- Il est indispensable que la direction administrative du milieu industriel d'accueil de la future banque de données affiche clairement son engagement dans le projet et manifeste concrètement cet engagement. L'exploitation de ce type d'outil fait parfois appel à un grand nombre d'intervenants différents. Plus ce nombre est grand et plus le risque d'une résistance au changement grandi.

  Il est nécessaire que la direction ait fait connaître à l'avance, qu'elle exigera que les intervenants documentent adéquatement leur position respective, s'il survenait des situations où des orientations ne seraient pas partagées.

  Cet appui affiché de la direction permettra dans bon nombre de cas d'éviter des situations gordiennes souvent inhérentes à des problèmes d'ordre plus relationnel que technique.
- Durant la rationalisation des besoins, un souci de transparence doit être rigoureusement respecté, tant à l'égard de la direction qu'à celui des futurs clients, fournisseurs et supports techniques. Il est nécessaire que tous les intervenants soient conscients des contraintes rencontrées, des choix qu'elles imposent. Ceci devrait faciliter l'obtention du consensus indispensable à la poursuite de l'implantation de la banque de données.
- Le recours à une expertise externe à l'entreprise, reconnue en matière d'implantation de banque de données, peut s'avérer avantageux afin d'éviter des écueils que seule une expérience éprouvée peut mettre en exergue.

  À l'instar d'un appui affiché de la direction, le recours à une expertise externe reconnue facilite l'obtention du consensus à établir autour des résultats de la rationalisation des besoins.
- Il est conseillé d'entériner chacune des phases de la méthodologie par l'obtention d'un résultat tangible (document) qui fasse l'objet de l'approbation de l'ensemble des intervenants. Il s'avérera même parfois préférable d'attendre l'adhésion de chacun d'entre eux aux choix retenus, plutôt que de vouloir gagner du temps en passant à une phase ultérieure et devoir y revenir par la suite pour effectuer des reprises, toujours coûteuses en énergie.
- Un écueil à éviter lors de la recherche des solutions pour pallier aux lacunes du milieu existant, est de concentrer les énergies sur une réponse uniquement basée sur l'acquisition d'un outil informatique.

  Les outils informatiques, qui bénéficient encore de l'aura accordé à toutes nouvelles technologies, passent souvent à tort dans l'inconscient collectif pour une panacée, réponse absolue à tous les problèmes existants.

  Par ailleurs, la recherche d'une correction à la source nécessite toujours des modifications d'activités officielles (processus, encadrements, etc.) et de réalités officieuses du terrain, qui s'avèrent particulièrement pénibles à mettre en oeuvre. **C'est pourtant cette remise en question des pratiques établies qui offrira les tous premiers résultats tangibles et garantira une pérennité à la future banque de données.**
- Enfin, au risque de paraître bien peu novateur,

il faut rappeler que la gestion d'un projet, tel que l'implantation d'une banque de données, nécessite souvent la consultation de plusieurs corps de métier, par conséquent, d'un nombre important d'individus aux attentes parfois divergentes, difficiles à contrôler.

Cet état de fait oblige immanquablement à adopter une structure très flexible avec à sa tête, un chargé de projet aux qualités reconnues. Ce choix judicieux d'un "leadership" (maîtrise des techniques de communication et de vulgarisation, reconnaissance assise des compétences dans diverses disciplines, impartialité à l'égard des solutions techniques possibles, habilité à la gestion d'une équipe multidisciplinaire, etc.) assure en grande partie le succès de la gestion d'une dynamique de groupe particulièrement difficile à obtenir.

Diverses raisons peuvent être évoquées :

- une banque de données est un outil unique devant satisfaire aux attentes d'intervenants aux préoccupations diverses, et pour qui la contribution ne paraît pas systématiquement complémentaire,
- chacun des intervenants aura tendance à essayer plus qu'à l'accoutumé, de tirer à lui les résultats de la rationalisation des besoins. Paradoxalement, l'idée reçue qu'une banque de données informatisée est la réponse facile à une partie importante des problèmes latents d'un outil de production, n'aide pas à son intégration,
- l'analyse du retour d'expérience, dans le cadre de l'exploitation d'une banque de données, est un travail très peu opérationnel, parfois ingrat, qui nécessite de la part des intervenants une clairvoyance accrue quant aux bénéfices qui peuvent en être retirés,
- les modifications annoncées des pratiques établies d'une organisation, imposées par l'exploitation d'une banque de données, rencontrent parfois des barrages de la part des intervenants potentiels. C'est l'inertie au changement,
- etc.

1 Conclusions

Les banques de données sont l'outil indispensable du retour d'expérience industriel. Mais sans des résultats tangibles et profitables à l'entreprise, issus de méthodes d'analyse connues, à quoi servent les banques de données ?

La définition et la rationalisation des besoins sont dès lors, des activités stratégiques pour l'industrie qui désire se pourvoir d'une banque de données.

La mise en oeuvre d'une méthodologie aide considérablement à l'exécution de ces activités. Par contre, le suivi de cette méthodologie n'assure pas un succès infaillible, ou simplement l'obtention de résultats satisfaisants.

Cependant une série d'enseignements, principalement d'ordre organisationnel (gestion des relations entre intervenants, participation de la direction, etc.) peuvent être énoncés. Ces derniers permettront d'éviter certains écueils connus de la définition et de la rationalisation des besoins en matière de banque de données. Ces enseignements peuvent facilement se généraliser au reste des étapes d'implantation d'une banque de données.

À la lumière de ces enseignements, il s'avère indubitable que les projets d'implantation d'une banque de données sont plus souvent des défis humains, que des challenges techniques.

2 Références

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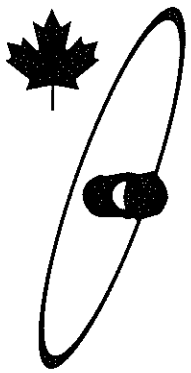

CANDU 9 Safety Enhancements and Licensability

by John Webb and Victor Snell

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Abstract

The CANDU 9 design has followed the evolutionary product development approach that has characterizedœthe CANDU family of nuclear power plants. In addition to utilizing proven equipment and systems from operating stations, the CANDU 9 design has looked ahead to incorporate design and safety enhancements necessary to meet evolving utility and regulatory requirements both in Canada and overseas.

To demonstrate licensability in Canada, and to assure overseas customers that the design had independent regulatory review in the country of origin, the pre-project program included an extensive two year formal review by the Atomic Energy Control Board (AECB). Documentation submitted for this licensing review included the licensing basis, safety requirements and safety analyses necessary to demonstrate compliance with regulations as well as to assess system design and performance. The licensing review was successfully completed in 1997 January. In addition, to facilitate licensability in Korea, CANDU 9 incorporates feedback from the application of Korean licensing requirements to the CANDU 6 reactors at Wolsong site.

1. Introduction

The CANDU product line is built around 700MWe and 900MWe class reactors. CANDU 6 (700Mwe class) reactors are operating in four countries, with five units of the latest version in operation or under construction in Korea and in China. There are 12 units of the CANDU 900MWe class currently operating in Canada at the Bruce and Darlington sites. The Bruce B and Darlington plants, each with four integrated creactor units, represent the second generation of the 900MWe class plants. The CANDU 9 design, with a gross output of 935MWe, is a single unit adaptation of these plants.

To satisfy client and regulatory expectations, both now and in the future, Atomic Energy of Canada Limited (AECL) has adopted an evolutionary approach in which the proven designs of the CANDU 6 and CANDU 9 products are improved incrementally and continually. This evolution is guided by the requirements of the operating utilities who look for:

- improved economics, through the reduction of plant capital and operating costs and project implementation risks;
- enhanced safety, through more reliable operation, more effective safety systems and greater resistance to severe accidents, and
- improved operability, through design simplification and the appropriate introduction of new technologies.

This paper summarizes the design and safety improvements of CANDU 9 and the results of the review by the AECB.

2. Significant Safety Enhancements

Safety enhancements for CANDU 9 either build on the inherent safety characteristics of the CANDU design (especially in the area of severe accidents) or respond to operating experience.

2.1 Radiation Protection

The CANDU 9 plant has been designed to comply with ICRP-60, the recommendations of the International Commission on Radiological Protection issued in 1991. These ICRP recommendations reduce the limits for occupational exposure dose to 20mSv/a, averaged over 5 years, and public exposure dose to 1mSv/a. As a design target, the CANDU 9 plant has been designed so that total worker exposures will be less than 1 person-Sv/a and the maximum exposure to a member of the public will be less than 50 μSv/a. Specific details are provided in Reference 3. The approach taken to reduce the internal exposures of workers and tritium emissions to the public has been to reduce tritium-in-air levels by upgrading the vapour-recovery system. The approach taken to reduce the external exposures of workers during shutdown conditions has been to improve equipment layout and reduce corrosion-product activity transport. Relatively easy access to the reactor building during plant operation has been a traditional CANDU advantage, and by careful attention to segregation of higher activity water vapour

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from lower activity areas this has been retained, while achieving the targets for total worker and public exposure.

2.2 Control Centre

For improved operational capabilities, the CANDU 9 design has incorporated an advanced control centre. Specific details are provided in Reference 4. The control centre layout incorporates the results of Human Factors analysis; a new computerized Plant Display System is separated from the digital control computer system; and the two computerized reactor shutdown systems have increased capability. The CANDU 9 control centre provides plant staff with a layout and information organization that is better matched to operational tasks.

A major evolutionary change from previous CANDU plants is the separation of the control from the display/annunciation features, both of which were formerly provided by the digital control computers (DCC). Control is now in the distributed control system (DCS) and display/annunciation is in the plant display system (PDS). This strategy allows powerful computers without application memory constraints or execution limits to provide extensive control, display or annunciation enhancements within an open architecture.

The control centre features standard panel human-machine interfaces that provide an integrated display and presentation philosophy; and includes the use of a common plant display system for all consoles and panels. A large , central overview display presents immediate and simplified plant status information to facilitate operation staff situational awareness in a legible and recognisable format. A powerful and flexible annunciation system provides extensive alarm filtering, prioritising and interrogation capabilities to enhance staff recognition of events and plant state.

The reactor shutdown computers for CANDU 9 include automated system testing and on-line neutronic trip calibration capabilities. One specific benefit of on-line calibration is an improved margin-to-trip . Safety system monitor computers provide automated safety system testing, resulting in shorter test duration with reduced opportunity for human error.

2.3 Severe Accidents Program

A severe loss-of-coolant accident in a CANDU does not necessarily imply severe core damage since, even in the absence of coolant and failure of emergency core cooling, the moderator acts as a heat sink and can preserve the pressure tube geometry without fuel melting. Therefore, if the moderator water can be cooled or even just topped up, core melt is not an issue. The CANDU 9 design underwent a systematic review to identify, prevent, and mitigate severe accidents. A detailed description of the program is provided in Reference 5. First, severe accidents and severe core damage frequency targets were set. A preliminary Probabilistic Safety Assessment was done early in design, and identified risk-dominant sequences. Changes required to meet the frequency targets for severe accidents were then identified and implemented.

While the overall severe accident program ensures a balance between preventative and mitigation measures, the role of the containment system is significant. For this reason, the licensing review noted the following enhanced features of the CANDU 9 containment:

- Large containment, with judicious layout of equipment resulting in large, open volumes, with good potential for natural circulation and no apparent hydrogen traps.
- Pre-stressed concrete boundary with steel liner resulting in increased design pressure (210kPa) and low leakage rate (0.2%/day)
- Large structural steel heat sinks that augment engineered safety systems provided to remove heat, moisture and fission product aerosols from the containment atmosphere
- Hydrogen mitigation systems that allow systematic and timely dispersion and reduction of hydrogen concentrations
- Instrumentation for measurements under accident conditions
- Reliable isolation of large containment penetrations through independence and diversity
- The elimination of the dousing system and the incorporation of the Reserve Water System.

The Reserve Water System is a storage and distribution system designed to deliver light water under gravity to a variety of systems whenever normal water sources are unavailable and make-up water is required. During normal operation, the system is isolated. The system consists of a large tank located at a high elevation within the reactor building, and is designed to provide make-up to the Heat Transport System, the Moderator System, the Steam Generators, the Emergency Core Cooling System and the Shield Cooling System. It has enough heat removal capacity for three days, so that severe accident management is relatively straightforward and decisions need not be made in haste.

Makeup from the Reserve Water System to the moderator, as noted, prevents fuel melting following a Loss of Cooling Accident and loss of Emergency Core Cooling (LOCA/LOECC). This is backed up again by makeup to the shield tank to remove decay heat by boiloff. Thus, even a severe core damage progression would be arrested at, or contained within, the calandria tank.

2.4 Grouping And Separation

The concept of grouping and separation of safety related systems has been an integral to CANDU plants. This concept provides physical and functional separation of safety related systems to ensure that common cause events do not impair the capability to perform essential safety functions. In this concept, the plant canœbe shut down, decay heat removed, and the plant conditions monitored independently from systems and components of either one of two groups, known as Group 1 and Group 2. For the CANDU 9 design, this concept has been enhanced through additional redundancy and diversity in the provision of cooling water and power supplies.

The main control room and the secondary control area are part of this concept. Although both have independent functions of shut down, cool, contain and monitor, the main control room can be used for all design basis accidents, including external events, so that the secondary control area is only required for a major fire or hostile takeover which requires an evacuation of the main control room. Both locations are qualified to operate during design basis and external events, and the necessary structures and systems have been appropriately protected and qualified.

2.5 Design Simplification

System reliability has been improved and the plant is more forgiving. Some examples are as follows:

- ECC component simplification, and reduction in the use of active components (replacement of valves by one-way rupture disks and ball seals)
- Longer operator action times, generally 8 hours for serious process failures; for example, the provision of a larger pressurizer improves the plant response following loss of flow events
- Design of the Shutdown Cooling System such that it can be placed in service under zero power, full pressure, hot conditions
- Improvements to heat sink redundancy and diversity in all shutdown conditions, e.g. high pressure Group 2 feedwater
- Reduction of manual operations such as the automation of the Group 2 feedwater system, automation of all ECC phases, and automatic startup of the Group 2 diesel generators for emergency power supply as a back up to the Group 1 Class III diesel generators.

2.6 Enhanced Human Factors Engineering

A formal Human Factors Engineering Program Plan (HFEPP) has been applied to all aspects of plant design for which there is an interface with plant personnel. This plan defines the process of incorporating human factors into the design of CANDU 9 system and equipment. Underlying this approach is a refined engineering design process that cost-effectively integrates operational feedback and human factors engineering to define operations staff information and information presentation requirements. As part of the CANDU 9 design strategy, a physical, full-scale mock-up of the control centre panels and consoles is being used for conceptual evaluation, rapid prototyping, design decision-making, and for the verification and validation of the design features, displays and operator interactions. The functionality of the simulation supported control centre mock-up provides a dynamic mechanism for the on-going verification and validation design activities by system designers.

3. AECB Licensing Review

3.1 The Review Process

Although CANDU 9 is based on operating CANDU nuclear power plants, foreign potential customers would likely require evidence of current licensability in the country of origin (Canada). Such evidence would dramatically reduce the risk of licensing-induced design changes once a project had been committed. It would also assure customers that the CANDU 9 design had been through a thorough independent review. Therefore, an intensive front licensing process, consisting of a two-year review by the AECB, was established to give this assurance. The finding sought from the AECB Staff was one of no fundamental barriers to licensability in Canada.

Although a further detailed licensing review would be done by the responsible regulatory authority afterœcommitment of the project, this front licensing assurance would allow such an authority to proceed with confidence. The review was done against the most recent regulatory requirements, that is, those in effect on 1 January 1995.

Although the "up-front" licensing approach is not new in Canada, this is the most extensive application of it to date. It is strongly supported by the AECB. In a recent paper, (Reference 1), the AECB stated its support as follows:

> "...the AECB believe that an agreement with designers and licensees on the basis for licensing and the safety-related design requirements, at a very early stage in the licensing process, will reduce the licensing risk for the owner; and the cost of modifications, should they be needed, will be much less."

The review process followed a structured and

logical approach. AECL first proposed a Licensing Plan to the AECB, giving the scope and schedule of the submissions. The AECB had numerous comments on this Plan, and a revised Plan, reflecting AECB requests for additional submissions (about a 50% increase in scope), was then agreed. The document submission schedule to the AECB ensured that design requirements were submitted and agreed first, followed by the description of how these requirements were implemented design and satisfied in safety analysis. This approach made it possible to complete the review in a two-year period.

Early in the review process, AECL submitted the Technical Description of the CANDU 9 to familiarize the AECB with the design and to initiate the licensing review. Along with this, AECL submitted the Licensing Basis Document (LBD), the high-level listing of the major licensing requirements. It calls up the appropriate regulatory documents and codes and standards, and interprets, in case of ambiguity, how the licensing requirements will be applied. This is a key part of Canadian licensing philosophy, in which the onus is on the designer to propose how the licensing requirements will be met, with the AECB accepting or rejecting the designers proposals. The LBD therefore included both AECB requirements and the requirements, as best they are known prior to the formal application for a license, of the foreign regulatory authorities, as well as lessons learned from previous licensing experience. The LBD, once accepted by the AECB, provides important guidance to a foreign regulatory authority on how licensability in Canada is implemented on CANDU 9.

These two early submissions were followed by more detailed design requirements documentation, design methods (e.g., for safety critical software), safety analyses analyses, probabilistic safety analysis, and other program documents such as quality assurance, decommissioning, safeguards, and security requirements. In selected cases, AECB inspected details of the design implementation. In total, over 200 formal documents were submitted. AECB review of the detailed submissions, while comprehensive, focused particularly on:

- new or unique features in the CANDU 9 design
- new or revised AECB Regulatory or Consultative documents
- Generic Action Items applying to all CANDU plants
- known operational safety issues
- importance to reactor safety

Midway through the review, the AECB staff identified thirteen key issues requiring a more detailed assessment. Intensive discussion took place for almost a year on these issues, resulting in many further submissions and analyses by AECL, and in some cases design changes, so that the issues could be closed at the end of the licensing review. To ensure that interested foreign customers were kept informed of the progress during the course of the review, the AECB issued two interim reports in June and September 1996 prior to the issue of the final report in January 1997.

3.2 Application of AECB Regulatory and Consultative documents

The AECB paper (Reference 1) notes the approach taken for the development of new regulatory requirements in Canada, as follows:

> "...new regulatory requirements for plants being designed today are based on a number of factors, including: a more rigorous application of the basic philosophy; operating experience of CANDU gained over the last 20 years; the steady development of knowledge about the behaviour of CANDU plants, and the capability of designers to predict accident behaviour; resolution of outstanding safety and licensing issues; introduction of human factors considerations during design and operation of the plant; continued increase in computerization in new designs; simplification of the design, operation and maintenance of the plant; and, improvements in severe core accident mitigation and management."

The CANDU 9 licensing review provided the first opportunity to implement a number of new or revised AECB regulatory and consultative documents. Among these were:

- R-7, Requirements for Containment Systems (effective date 1991 February)
- R-8, Requirements for Shutdown Systems (effective date 1991 February)
- R-9, Requirements for Emergency Core Cooling Systems (effective date 1991 February)
- R-90, Policy on Decommissioning of Nuclear Facilities (effective date 1988 August)
- C-98, Rev. 1, Reliability Requirements for Safety Related Systems of Nuclear Reactor Facilities (draft dated 1995 March)
- C-129, The Requirements to Keep All Exposures As Low As Reasonably Achievable (draft issued for comments 1994 July)

Despite the draft nature of some of these documents, CANDU 9 was designed for compliance, in anticipation that the documents would be issued or approved by the time of application for a

Construction Licence. To record this, a series of Compliance Documents was produced. They provide an audit trail for the regulator on the detailed implementation of the requirements in the design. These live documents will be updated during the project phase, and carried over to plant commissioning and operation to ensure that operating and maintenance procedures comply with the regulatory requirements.

3.3 Response to Generic Action Items

The AECB uses Generic Action Items (GAI) to track the progress in resolving licensing issues common to operating CANDU reactors. For the CANDU 9 licensing review, the AECB required that:

- design solutions shall be provided for GAI's, whenever feasible,
- the plans and schedules for resolution of the issues shall be documented, and
- sufficient safety margins shall be shown, or future design improvements should not be precluded.

The CANDU 9 addresses *all* the current GAI's through a combination of design changes, consideration in the design process or R&D support. As an example of a design change, the single loop Heat Transport System in combination with a large pressurizer addressed the concern of GAI 90G02, Core cooling inœthe Absence of Forced Flow, since the HTS is always single phase for accidents which tend to cool and shrink the coolant, so that thermosyphoning is more easily demonstrated. As an example of a design process, the CANDU 9 approach has been to systematically identify measures taken in the design stage to achieve the goals of plant life management and to address GAI 90G03, Management of Aging. An overall review of the CANDU Plant Life anagement (PLIM) program is provided in Reference 2. As an example of R&D support, an industry-wide program to upgrade the validation of safety analysis codes, including the two-phase non-equilibrium transient thermohydraulics code CATHENA code, was the response to GAI 94G01, Emergency Core Cooling Effectiveness, since it established confidence in the predictions of CATHENA.

3.4 AECB Summary and Conclusions

The summary statement of the AECB licensing review for the CANDU 9 design reads as follows:

> "AECB staff conclude that there are no fundamental barriers to CANDU 9 licensability in Canada."

This statement results from the review of the information provided to the AECB, and is based on three general conclusions: that the CANDU 9 design complies, or can be made to comply with licensing requirements in effect, in Canada, on January 1, 1995; that the proposals to address AECB Generic Action Items on the CANDU 9 design are acceptable; and that the major issues identified during the course of the licensing review have been adequately addressed. This has been a successful application of front licensing . Prospective owners can take comfort in the consequential reduction of licensing risk to the project.

Summary and Conclusions

CANDU 9 is a stand-alone version of the successful multi-unit Darlington and Bruce Nuclear Generating Stations operating in Ontario, Canada. Added to the advantages of using proven systems and components, CANDU 9 offers a higher electrical output, better site utilization, shorter construction time, improved station layout and better operability. Significant progress has been made on the CANDU 9 Basic Engineering Program, and in 1997 January, the licensing review of CANDU 9 design was completed by the Canadian Regulatory Agency, the AECB, and the final report issued. In addition to identifying a number of CANDU 9 improvements over previous CANDU designs, the AECB concluded that there were no fundamental barriers to CANDU 9 licensability in Canada.

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1. J.D. Waddington, "Power Reactor Licensing in Canada, 1995", presented at the KAIF/CNA CANDU Seminar, Seoul, Korea, 1996 May
2. B.A. Shalaby and E.G. Price, Plant Life Management and Extension for CANDU NPP, presented at NUTHOS 5, Beijing, China, 1997 April.
3. C.R. Boss, P.J. Allsop and N. Gagnon, "Compliance of CANDU Nuclear Power Plants with ICRP60", presented at the 12th KAIF/KNS Annual Conference, Seoul, Korea, 1997 April.
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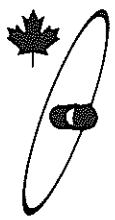
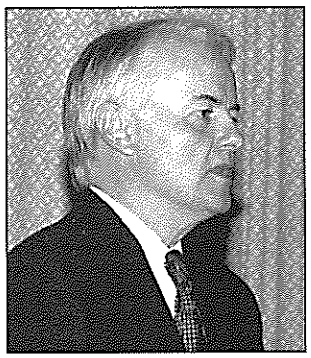
5. S.M. Nijhawan, A.L. Wight and V.G. Snell, Addressing Severe Accidents in the CANDU 9 Design, presented at the IAEA Technical Committee meeting on Impact of Severe Accidents on Plant Design and Layout of Advanced Water Cooled Reactors, Vienna, 1996 October.



CNA/CNS Annual Conference

Over 350 delegates assembled at the Inn-on-the-Park hotel in Toronto from June 8 to 11 for the 1997 joint Annual Conference of the Canadian Nuclear Association and The Canadian Nuclear Society. This was the 37th annual conference for the CNA and the 18th for the CNS.



Norm Sterling

As has been the pattern for the past few years the first morning was a joint plenary session, with four keynote speakers: **Allan Kupcis**, president and CEO of Ontario Hydro; **Reid Morden**, president and CEO of Atomic Energy of Canada Limited, **Bernard Michel**, president and CEO of Cameco; and **Paul Koenderman**, senior vice-president of Babcock-Wilcox. They dealt with four aspects of "The Nuclear Vision", the theme of the session. Kupcis spoke on the question, "Can Nuclear Compete in the New Market Place?", Morden tackled "Meeting the Global Challenge", Michel reviewed "Canada as a World Uranium Supplier" and Koenderman gave his views on "Partnering for Canada's Nuclear Future" (Parts of Kupcis' and Morden's talks are presented in this issue of the CNS Bulletin.)

Norm Sterling, the Ontario Minister of Environment and Energy (and the Minister to whom Ontario Hydro reports) was the guest speaker at the first luncheon.

Sterling stated his government's support of Ontario Hydro but emphasized that their priority is "the necessity for uncompromised safety in the operation of our nuclear facilities". He referred to the creation of a Nuclear Review Committee within Ontario Hydro's Board and the appointment of the seven member team to "lead and manage a nuclear excellence program".

Sterling then turned to what he called "the competitiveness challenge", noting that several countries and many US states had opened their electricity markets. Competitive energy pricing is also needed to support his government's aim for Ontario's economy, he stated. There will be "a period of transition" during which the government intends to "set in place a regulatory framework for customer protection and provision for safety, reliability financial stability and environmental integrity". He contended that competition "will build up the industry's muscle power", referring to the achievements in the U.K.

"Ontario has invested heavily in nuclear power", he said, and "we will safeguard that investment carefully",but, nevertheless, the province's electricity market must be opened to competition. "I am talking about competition NOT privatization at this stage", he emphasized. But there must be "safety of nuclear operations and assurances that customers are well served - with equitable rates, high reliability, improved service. "If you are up to the challenge, the government will do its part", he stated in closing.

The Monday afternoon CNA session focused on International Opportunities, with papers on the Korean situation, financing, international negotiations, and international opportunities for CANDU. On the Tuesday, the CNA sessions dealt with Competition in the Marketplace with talks ranging from "Pickering's Return to Operational Excellence" by Ken Talbot to "Lessons from the 'New' Bell" by Ian McElroy, executive vice-president of Bell Canada. Closing the CNA conference on the Wednesday morning was a session on "Opportunities in the Late '90s" with presentations on topics such as "MOX Fuel - A Catalyst for Disarmament" and "Thermalnuclear Fusion and ITER"

The CNS Conference ran from Monday noon to Wednesday afternoon, in parallel with the CNA sessions. Almost 100 technical papers were presented. (The detailed program was distributed to all CNS members prior to the conference.) Proceedings, in two volumes, are available from the CNS office.

This year the CNA presented its awards at the end of the first morning session, prior to the lunch, which proved to be a successful arrangement. The CNS awards were presented after the talk by Dr. Margaret Maxey at the lunch on the second day. Separate articles provide details on the CNS and CNA awards.

At the final luncheon the guest speaker was TV and radio host Rex Murphy who gave an erudite and entertaining review of Canadian politics.

In place of the traditional banquet delegates were bussed to downtown Toronto for dinner and a presentation of the musical "Beauty and the Beast" followed by coffee and dessert with the cast.

Despite being in Toronto, the locale for many CNS members, the attendance at the CNS technical sessions was lower than at recent conferences. Some delegates commented that this year's CNA program was more interesting and attracted some who otherwise would have attended the technical sessions. Next year the CNS will run a separate annual conference while the CNA will hold its conference in conjunction with the PBNC conference in Banff. However, the overall opinion of most delegates appeared to be that this year's joint conference was an interesting and successful event.

1997 Honours and Awards

CNS president Hong Huynh (L) presents the newly created CNS "Education and Communication Award", for the first time, to Dr. Aslam Lone at the CNA/CNS Annual Conference in Toronto, June 10, 1997

CNS president Hong Huynh (L) presents certificates designating their appointment as Fellows of the Canadian Nuclear Society to Dr. Paul Fehrenbach (top) and Ed Price, at the CNA/CNS Annual Conference, June 10, 1997

Each year the Canadian Nuclear Society presents honours and awards to recognize the contributions of certain members to the field of nuclear science and technology and to the Society.

These are typically presented during the CNA/CNS Annual Conference

At this year's Annual Conference, held in Toronto from June 8 to 11, the Education and Communication Award and the J.S. Hewitt Team Achievement Award were presented and two CNS Fellows were named.

The John S. Hewitt Team Achievement Award was established in 1994 in memory of John Hewitt one of the founders and early presidents of the Canadian Nuclear Society. The award is to recognize outstanding achievement in the introduction or implementation of new concepts of the attainment of difficult goals in the nuclear field in Canada. This year the award was presented tot the Joint AECL - Ontario Hydro Team for the Development of the concept for Disposal of

Canada's Used Nuclear Fuel from the beginning of the project in 1978 through to the submission of the Environmental Impact Statement in 19994 and subsequent defence of the EIS. Among the achievements cited were: development of a

soundly based and scientifically defensible understanding of how the engineered barriers will perform; development of an understanding of the processes governing groundwater flow in the Canadian shield; construction of the Underground Research Laboratory; development of the probabilistic risk assessment methodology and the SYVAC code; development of the biosphere model for performance assessment; development of conceptual systems for transportation of used fuel. The award was presented to Dr. Ken Dormuth of AECL and Dr. K. Johansen of Ontario Hydro on behalf of their respective teams

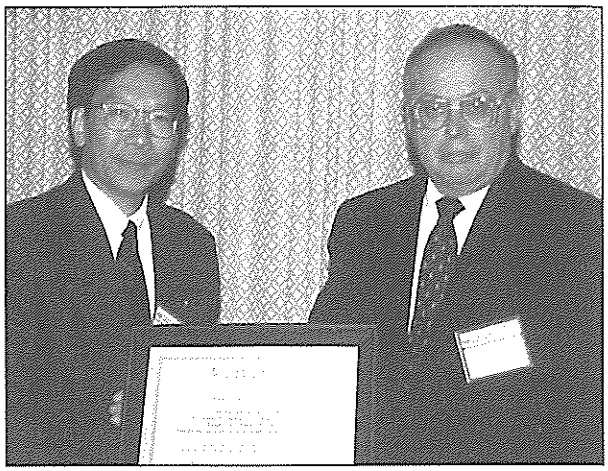
The Education and Communication Award was created this past year to recognize significant achievement by a CNS member in encouraging students to pursue science, engineering and mathematics, especially as they relate to nuclear science and technology, or achievement in successfully communicating to educators, students, members of the public, media and governments, the benefits of nuclear science and technology.

The 1997 Education and Communication Award was given to **Aslam Lone**, a nuclear physicist at AECL Chalk River Laboratories. Aslam chaired the CNS Education and Communications Committee for four years during which he put together a series of hands-on experiments to demonstrate the properties and uses of nuclear radiation which have been used at the Chalk River Science for Educators Seminar and at several educators workshops.

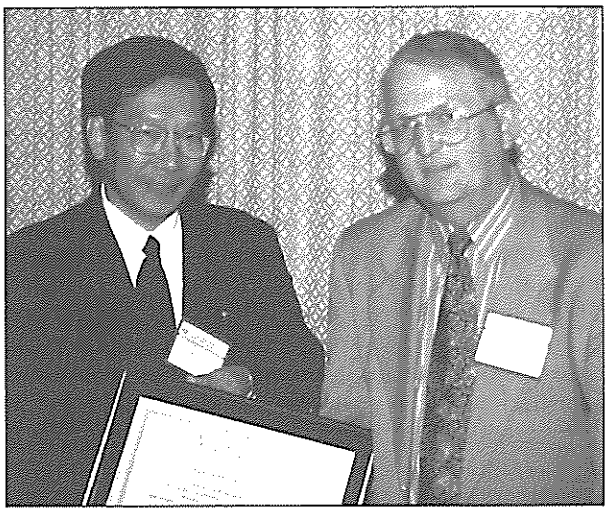
Aslam was also instrumental in starting the successful speakers program in the Chalk River Branch of the CNS and instituted joint seminars with the community college in Pembroke.

Fellows of the Canadian Nuclear Society are distinguished members of the Society who have made major and sustained contributions to the science or professions that relate tot he advancement of nuclear technology in Canada. Other criteria are demonstrated maturity of judgement and breadth of experience, and current membership in the CNS for at least five years standing. This year two Fellows were named

Paul Fehrenbach is currently Site Head of AECL's Chalk River Laboratories and General Manager of CANDU Technology Development. He joined AECL in 1971 after receiving a Ph.D. from the University of Waterloo in physical metallurgy. In 1988 he was named head of the Fuel Engineering Branch and subsequently has held several managerial positions. He is a charter member of the Canadian Nuclear Society and became its president in 1993-94. In addition he has served on several CNS committees and is currently a key member of the organizing committee for the Pacific Basin Nuclear Conference (PBNC 98) that will be held in Banff in May 1998. He has represented the CNS on the International Nuclear Societies council and the Pacific Nuclear Council.



CNS president Hong Huynh presents the CNS "John Hewitt Team Achievement Award" to Dr. Ken Dormuth (top) of AECL and Kurt Johansen of Ontario Hydro representing the joing AECL-Ontario Hydro team for the "Development of the Concept for Disposal of Canada's Used Nuclear Fuel", during the CNA/CNS Annual Conference, June 10, 1997



Ed Price is also a past-president of the CNS, having served in that role in 1994-95. He is currently Director, Materials Engineering in the Chief Engineer's office at AECL Sheridan Park. A native of New Zealand Ed joined AECL in 1971 after eight years with Orenda (Canada) Limited. He has been very much involved in problems associated with pressure tubes and in standards development He remains active in the CNS as a member of the Council of the Society.

CNA Awards

On June 9, 1997, during the CNA/CNS Annual Conference, the Canadian Nuclear Association presented its yearly awards. Dick Williams, recently retired from Natural Resources Canada, was chairman of the CNA Awards Committee and announced the winners.

There were two recipients of the **Outstanding Achievement Award**. This Award was established in 1989 to recognize individuals, organizations or parts of organizations who have made significant and obvious contributions to the nuclear industry over a long period of time and / or who have made **specific** outstanding individual contributions that have had a significantly positive impact on the Canadian nuclear industry.

The first winner was:

James C. Smith, Director, Nuclear Steam Generators and Components Marketing, for Babcock & Wilcox Canada.

In the citation Williams noted that Jim Smith has become widely recognized and respected by key nuclear utility managers in Canada, the United States and elsewhere. He is highly respected not only as a technical expert on Recirculating Nuclear Steam Generators, but also as a creative marketeer working to solve customer needs. He took the company's CANDU experience and capitalized on it in other markets. Through his leadership, the company went from zero market share in Replacement Nuclear Steam Generators, to capturing 75 per cent of the U.S. market over a five year period during the early 1990s.

The second recipient was:

Dr. Alistair Miller, Project Manager, Heavy Water Production Processes, Atomic Energy of Canada Limited at Chalk River..

Alistair is an internationally recognized authority on the modeling, design and optimization of Girdler-Sulphide heavy water plants, and on the technical aspects of hydrogen isotope separation for heavy water production , heavy water upgrading, and tritium removal. He has made a significant contribution to the Canadian nuclear program in the field of heavy water and hydrogen isotope separation. Joining AECL in 1966 as a member of the Heavy Water Group in the Chemical Engineering Branch, he became Section Head in charge of simulation and process design and was appointed Manager of the Chemical Engineering Branch in 1982. In late 1995, he was appointed Project Manager, Heavy Water Production Processes, responsible for the industrial demonstration and deployment of the Combined Industrial Reforming and Catalytic Exchange (CIRCE) and the Combined Electrolysis and Catalytic Exchange (CECE) processes for heavy water production. Alistair is an internationally recognized authority on the modeling, design and optimization of Girdler-Sulphide heavy water plants, and on the technical aspects of hydrogen isotope separation for heavy water production , heavy water upgrading, and tritium removal.

The **Ian McRae Award** was established in 1973 in honour of the late Ian McRae, the first President of the CNA. This Award recognizes individuals for their outstanding contributions to the general advancement of nuclear energy in Canada, through such fields of activity as management, administration, public service, medicine, communication and the arts.

The 1997 recipient was **Dr. Ralph Green**, former Vice-President of Reactor Development with AECL.

Ralph Green had a 35-year career with AECL, first as a scientist, then as a technical manager, as a Senior technical Advisor and, finally, as a senior Executive. As a scientist, he was first involved in experiments at Chalk River that provided the data that were invaluable in the benchmarking of the reactor physics methods and codes used in the design of CANDU reactors, beginning with NPD, Douglas Point, Gentilly-1, and Pickering. In the l960s, he led a team of scientists, engineers and technologists which designed and built one of the world's first continuous wave accelerators. He had the vision in 1968 to appreciate that an intense electron beam could be an alternative to Cobalt 60 for industrial applications.

As a technical manager, he led several programs that have had a lasting impact on the CANDU business. As a Senior Advisor to the Executive Vice-President, he was responsible for advising on, and monitoring all of AECL's research programs on CANDU reactors and advanced fuel cycles, and for interaction with government agencies on safeguards for export reactors.

CNA chairman, Ernie Cord, presents the Ian McRae Award to Dr. Ralph Green for his many contributions in various managerial and executive positions during his long career with AECL; during the CNA/CNS Annual Conference, June 1997

Doug Chambers (R) receives the Dr. W.B. Lewis Medal from CNA chairman Ernie Cord during the CNA/CNS Annual Conference in Toronto, June 9, 1997

He took charge of the Whiteshell site, immediately following the acquisition of increased funding for the Nuclear Fuel Waste Management program, and oversaw a significant expansion in that program, including construction of the Underground Research Laboratory.

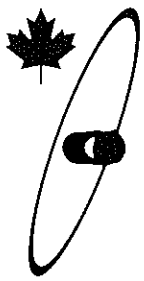
Ralph played a decisive role in the focusing of the industry-wide effort in CANDU R&D. In 1989, as an outcome of the federal/provincial negotiations in which he played a key role, the CANDU program was able to retain substantial support from the federal government and also achieve more cost sharing of CANDU R&D with the utilities.

The **W.B. Lewis Medal** was established in 1973, in honour of the late Dr. W.B. Lewis. The Medal recognizes Canadian scientists or engineers who have demonstrated a level of technical competence and accomplishment in the field of nuclear science and engineering, as exemplified by Dr. Lewis during his involvement in the Canadian nuclear energy program from 1946 to 1973.

The 1997 winner **Douglas B. Chambers,** Executive Vice-President and Director of Radioactivity and Risk Studies for SENES Consultants Limited.

Doug Chambers has had a long involvement with workplace radiation assessment and radiation protection and is a recognized expert on uranium mining. He has wide experience in the evaluation of exposure of uranium miners to radon progeny at former uranium mines, and in analyses in support of decommissioning programs for uranium production operations. He has participated in the development of radiation protection measures for several of the new, high-grade underground uranium mining projects in northern Saskatchewan, and has developed models of assessment of gamma radiation and for radon that have been widely used and tested.

Doug has also directed and participated in numerous studies on environmental and occupational health and risk. Risk assessments performed under his direction include radiological risks from electrical generation with CANDU reactors, phosphogypsum stacks, and uranium mines in Canada, and elsewhere. He has also been an active participant in numerous studies that utilized multi-media environmental pathways analysis, and other modeling techniques, to investigate the release, distribution, and effect of both radioactive and non-radioactive species in the environment.



Can Nuclear Compete?

By Allan Kupcis

Ed. Note: *Dr. Allan Kupcis, president and CEO of Ontario Hydro, gave the first (of four) keynote addresses at the CNA/CNS Annual conference in Toronto, 8 - 11 June 1997. His topic was "Can Nuclear Compete in the New Market Place ?" Following is a slightly edited version of Dr. Kupcis' notes. In his address he adhered closely to his notes with one notable additional comment when reviewing the problems at Ontario Hydro's nuclear plants. In what might be considered a Freudian slip he said, "the root causes were genetic" then quickly corrected himself and said "generic".*

Dr. Allan Kupcis

I want to address where we at Ontario Hydro are going and describe for you some of the strategic thinking and tactical action that will be required to achieve our grand goals. But first, let me pose the key question that each of us must ask ourselves. The question is this: Can nuclear compete?

I'd like to say that the answer is an unequivocal 'yes,' but I cannot at this time. Under certain circumstances the answer could even be a resounding 'no.' Under the sort of scenario we'd all rather see, the answer just might be 'yes.'

But in the process of getting to 'yes', there are a few 'ifs' along the way. For a tiny two-letter work, 'if' can have some major implications.

A major consideration that must be taken into account, is that we are in the business of providing electrical energy and service to customers. At Ontario Hydro, despite the fact that the majority of our electricity generation is nuclear, we are not wedded to nuclear or any other particular technology.

We have inherited our nuclear technology and we are currently living through some well publicized problems. I want to review those problems for you and tell you how we are tackling the issues, but first let me give you a thumbnail sketch of Ontario Hydro.

Ontario Hydro is one of the largest utilities in North America measured by installed generating capacity. We serve almost one million customers through our retail operations, more than one hundred large direct clients, and more than three hundred municipal electrical utilities. But, in a global... or even a North American context... we are becoming relatively smaller just by standing still.

Ontario Hydro has three nuclear sites that in 1996 satisfied 54% of the province's demand for electricity. Hydroelectric stations supplied 26% and coal-fired stations supplied a further 13%.

We've been around since 1906 and, as some of you may know, may soon be undergoing changes at the hands of our shareholder, the Government of Ontario. Our future has been under close scrutiny for a little more than a year now since the release of the Macdonald Committee report. While determination of the final approach has yet to be made, we have not been idle. The world has become too competitive a place for us to simply sit back.

We have reorganized ourselves into three new, signature companies:

- The first is an electrical power generation company that is one of the largest in North America;
- the second is a transmission network with a vast and reliable network for transmitting power inside the province as well as the ability to market 4,000 megawatts outside our borders [as well;]
- and the third company is a retail business with a built-in base of about one million customers.

At the same time, we've proposed divestiture of our System Control Centre to ensure non-discriminatory access for suppliers and customers alike to the common carrier.

We have taken bold steps to improve our bottom line. In the last four years we have reduced staff by 30% and increased productivity by 50%. We have retired debt of $3.5 billion and plan to retire a further $4 billion over the next three years.

There have been notable external achievements, too. We froze average rates for the past four years and we remain committed to no increase in average rates for the rest of this decade.

That's a brief look at the corporate profile of Ontario Hydro. Now I want to turn to our nuclear facilities.

CNS 1997 Annual Conference

List of Papers

Note: A two-volume set of Proceedings, which includes copies of full papers as listed below, is available from the CNS office. Contact Sylvie Caron, tel. 416-977-7620 ext 18; fax 416-979-8356; e-mail: carons@cna.ca

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- ❑ **On the Other Properties of Quadruple Melted Zr-2.5 Nb Pressure Tubes**
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- ❑ **Mechanisms for Preventing Deuterium Ingress at Rolled Joints in CANDU Fuel Channels**
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During the past decade, our nuclear program as a whole has not met its own yearly targets, never mind the corporate expectations of performance. As I mentioned nuclear contributed 54% of generation last year... that's down from more than 60% in recent years.

Nuclear requires a disciplined assignment and individual acceptance of accountabilities, and must be managed with unwavering attention to people, process, and plant performance.

By contrast to best international practices, we had deep-seated problems in the management of safety and performance of our plants. These were manifested in weaknesses in setting and communicating performance standards. Over time, we suffered from a general lace of "formality". By that I mean we didn't adhere to a coherent and consistent set of principles and standard procedures. As a result, our programs and activities at all levels didn't reach acceptable levels of quality.

Moreover, problems of long-standing were often not even acknowledged, let alone acted upon. Employee safety performance was generally poor and slow to improve. In short, we lost our focus on operations, and this was compounded by unclear and undefined accountabilities.

We had deep-seated problems in the management of safety and performance

This is not an easy confession. At Ontario Hydro, we got too cocky and we got our comeuppance.

But you know what they say, a good scare is worth more than good advice.

We survived and we learned how far we must go to correct the problems.

This newly acquired insight has come as a bit of a shock to some people within our organization. We enjoy being in the top ten lists world-wide in terms of annual capacity factor and lifetime ratings. We no longer find ourselves in such exalted company. For a while, there was a certain amount of denial of the new reality, but there is now an across-the-board recognition that our recent performance is absolutely unacceptable.

The dilemma in the past was that we would identify the problems, put plans in place to rectify what was wrong, and only later discover that the proposed solutions were ineffective. It became clear that we needed a new approach. We looked around for those who have turned nuclear performance around for other utilities.

This led us to hire a seven-member nuclear recovery team, headed by Carl Andognini as chief nuclear officer. The team is now in the discovery phase, assessing every aspect of our nuclear stations, en route to presenting a turnaround action plan that will solve the problems and reinvigorate management culture.

On the larger question of overall performance, I am well aware that difficult decisions will be required. The good news, however, is that dramatic performance improvements are not only possible but also that the team we now have in place has successfully accomplished those types of turnarounds elsewhere. I am confident that within three years, Ontario Hydro's nuclear fleet will be well on the way to reclaiming the top standings we once held as world-class producers.

How will we know when we've arrived? We will be guided and measured by peer reviews conducted by the World Association of Nuclear Operators (WANO). We selected WANO because those reviews are independent and credible. Moreover, the WANO benchmarks are international in nature and that means we will be measured... as we should be... against global excellence.

Last month, I was honoured to be named the fifth president of WANO. I aim to carry out the WANO mission at home and abroad. That mission is clear: to maximize the safety and reliability of the world's nuclear operations through communication, comparison and emulation. That's a mission that matters to everyone residing on this planet.

That does not mean that we at Ontario Hydro are unthinking champions of nuclear power. Nuclear does have environmental benefits. The U.S. Department of Energy recently released some figures showing that by the year 2015 world emissions of carbon from the combustion of fossil fuels for energy production will have increased 61% over 1990 levels. The problem is most noticeable in the eastern portion of North America, the very market we week to serve.

That kind of reality, makes it all the more important that we achieve the turnaround that we seek and get our environmentally sound nuclear operations running well again.

Falling behind is utter failure

Competitive advantage is what this game is all about. Nuclear will have to reconfirm its worth to us and its value to the community at large in terms of its ongoing performance.

Nuclear can only be competitive as long as all the 'ifs' can be satisfied. The pressure is on to satisfy those 'ifs' because in an increasingly competi-

tive world, standing still is not good enough. Falling behind is utter failure.

Customers have become demanding. Customers are not only getting used to choice in natural gas, telecommunications and other recently deregulated industries, those customers are also demanding even more alternatives, lower costs, and improved service. While customers cannot yet pick and choose their electricity supplier, that time is not far off.

Anyone who isn't listening to that clamour and responding with clarity won't be around by the turn of the century. They'll be put out to pasture like the old gray mare at the time of the industrial revolution. Improved productivity, lower costs, innovative programs and services... these are the watchwords, not of the next millennium, but of this very month.

Competition has become a fact of life in the United Kingdom, Norway, Sweden, Finland, Australia and the United States. in the U.S., wholesale access was implemented in 1992, and almost all of the states in our market area are firmly committed to universal customer choice.

The North American electricity market amounts to $225 billion annually. If we expect to export power those jurisdictions, we cannot keep the competition at bay. Monopolies like Ontario Hydro cannot retain their strangleholds, nor do we have any such expectations. Indeed, some U.S. operators are already here. Enron and American Electric Power have established offices in Toronto.

We believe nuclear can be competitive

A competitive environment offers benefits for producers just as such competition benefits customers. With lower prices, additional products and services that are innovative and value-added, everybody will be eyeing everyone else's market.

Where does nuclear fit in all of this? If you ask leaders in the industry whether nuclear can compete in the generation of electricity the answer is mixed. A majority of electric utility executives across North America who were recently surveyed on this very question were pretty evenly split on the topic: 44% of executives believed that nuclear can compete, but 33% said nuclear cannot compete and a further 23% were not sure. That means a majority... some 56% of respondents... were either negative or uncertain. In an election, any political party seeing that kind of ambivalence would be very concerned.

At Ontario Hydro, we place ourselves firmly in the positive camp, among the 44% who believe nuclear can be competitive... but again I want to add that all-important word 'if'. If we can get our house in order by improving safety performance, controlling costs and increasing productivity.

In the coming days, the Government of Ontario is expected to issue a white paper that will detail the proposed shape of a new competitive marketplace for electricity in this province. Decisions will flow following a period of public discussion but, meanwhile, we at Ontario Hydro continue to prepare for that new world... as we have been doing for the last three years... as we restructure, improve our financial state, and make the organization more business-like.

The market must prevail

We cannot afford to fail and we will not fail. When we have restored our nuclear units to the performance levels that I believe are again possible, we will be well positioned not just to serve your traditional market, but to actively pursue new customers in other markets as well.

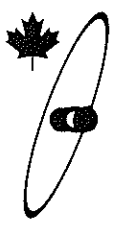
The successful players of tomorrow will either be giants or niche players. Ontario Hydro appears big enough, but from a North American perspective, we are not. There are already half a dozen U.S. entities that are larger than Ontario Hydro in terms of annual revenues and at the present pace of merger activity, more megafirms are certain to be created.

Our challenge, then, goes well beyond nuclear, important though that energy source is. Monopoly control of electricity in Ontario must end. The market must prevail. Ontario Hydro must become a customer-focused commercial enterprise operating in an electricity market that is open to any producer or supplier.

At the same time, our challenge is to continue growing so that we can rank among the major players in North America. Canada is an export economy; we want to be an expanding participant.

Ontario Hydro began as the dream of one man, Sir Adam Beck, almost a century ago. his vision remains very much alive today.

I am confident that our CANDU technology, managed with unwavering attention to excellence in safety, cost and production, will help us meet the challenges that lie ahead in the next century.



Meeting the Challenge of Public Acceptance

by Reid Morden

Ed. Note: *Reid Morden, president and CEO of Atomic energy of Canada Limited, was the second keynote speaker at the CNA/CNS Annual Conference, 9 June 1997. Although his topic and the title of his address was "Meeting the Global Challenge" Morden chose to focus more on the problem of public acceptance. Following are excerpts from his address.*

Last year I made the case that Canada's nuclear future will be shaped abroad, particularly in the industrializing world.

Since then we have made important progress.

- The China project is now underway. The ground has been broken.

  Canada's share of this contract will amount to $1.5 billion – providing 27,000 person years of work through over 125 private sector companies, many of whom are represented here today.

  We have opened the door. Now, we must persist.

  I believe that it is entirely within reason for us to be able to target at least 25% of China's announced goal of 40,000 MWe installed nuclear capacity by the year 2020.

  Reaching that goal will require first class performance on the Qinshan project – meeting or beating the schedule. It will require adequate and innovative financing for an ambitious Chinese nuclear program. And it will demand localization – a key to our success in Korea and elsewhere.
- Next we are hard at work pulling together a bid for Turkey. This is a truly competitive contest. We have a strong consortium. We will table a very attractive bid. Financing is always a major challenge, but we will have a competitive financing package.
- In Korea, we expect a decision soon on whether two CANDU 9 units will be included in their basic construction plan. This is vital. It will determine whether that country will continue with its far-sighted two-reactor policy – and it would be our first opportunity to build a CANDU 9 abroad.
- In Romania, acute energy demand coupled with the excellent performance of unit one at Cernavoda has, we believe, enhanced our prospects of securing a contract for unit two. Bob Nixon, our Chairman, and I met recently our customer and the leaders of the new Romanian government. They have made completion of Unit 2 a national priority and we have followed up by putting a proposal forward with our Italian partners, Ansaldo.
- Next, an opportunity has emerged in Hungary. They requested – and paid for themselves – a feasibility study for two CANDU 6's at the PAK's site. That study has now been completed.
- Finally, we are continuing to pursue opportunities in Southeast Asia – in particular in Indonesia, the Philippines and Thailand. All three aim to have nuclear power in place by around the year 2008, only ten years hence. At the same time, we are also exploring possibilities in Vietnam.

This update speaks for itself.

Ours is not a sunset industry. It is a sunrise industry. As Mark Twain might say, the rumours of our demise have been greatly exaggerated.

Of course, there are no laurels to rest on here.

With very tight budgets and very strong competition, our nuclear alliance – Team CANDU, more than ever, must reflect, not the rhetoric of collaboration, but the reality.

Many of our customers have ready access to fossil fuels and investors willing to fund IPPs. Our need for cost reduction and enhanced performance is clear.

Furthermore, we must continue to develop strong and reliable strategic alliances abroad. We must develop new sources and new strategies for financing. We must be aggressive at localization. And we must continue to press ahead with a permanent solution for waste disposal.

All that represents a tall order. But is does not fully describe the challenges we must meet.

Because, in the end, the future of our industry will depend not on our technology or our efficiency or on the disposal of waste, although each of these is obviously very important. The ultimate test we must pass is that of public acceptance – indeed active public support – for the proposition that we, the Canadian nuclear industry, have a viable, safe and clean alternative here that can

help meet the energy needs of Canada – and the glove.

Most of us are not used to a pre-occupation with public opinion. We are scientists or engineers, business people or project leaders. By and large, we leave public opinion to others.

Public opinion matters when decisions are made to cut – or sustain – funding. Public opinion matters when the issue of financing our exports is considered. Public opinion matters and is growing in importance in our foreign markets. And public opinion will certainly matter when the future of nuclear power in this country returns to the top of the energy agenda.

We have, too often, left the field open to the anti-nuclear lobby. We allow misstatement and inaccuracies to stand. We are silent while unwarranted fears are fomented and deep emotional attitudes are formed.

The fact is we have a very good story to tell. We simply aren't telling it well enough, or often enough.

The difficulties we face are not trivial. The science of nuclear power is complex – and therefore easy to distort by pseudo-experts. The origins of nuclear power – coincident in the minds of many with the atom bomb and the Cold War – make it easy to create a sense of guilt by association. The media – themselves seldom schooled in science and perpetually in search of a provocative story – create an automatic pulpit for anti-nuclear activists, whose credentials are seldom held up to scrutiny.

This is a serious matter of public policy. It is, therefore, a legitimate matter for responsible debate.

There is no requirement for the anti-nuclear lobby to be responsible. They are not responsible to taxpayers, nor to electors. Their business is influence not education, diatribe not debate.

I believe it is time to make this a responsible debate. It is time to get the facts out. It is time to tell our story.

One argument made is that sustainable development means no nuclear power.

Here, the anti-nuclear lobby is most inconsistent and disingenuous.

Nuclear power producers no greenhouse gases, no nitrogen oxide, no sulphur dioxide and no heavy metals.

If there were no nuclear power in the world and that energy were derived instead from coal, every year would see 2.6 billion additional tons of carbon dioxide, 2 million extra tons of sulphur dioxide, 1 million extra tons of nitrogen oxides and about 150,000 more tons of poisonous heavy metals released into the atmosphere.

When the anti nuclear lobby says that industrializing countries should not have access to nuclear power, they are, in effect, saying **'let them burn coal'**.

I will not mince words. Anyone who ponders the threat posed by global warming, and who considers for even a minute the demographic and economic trends, particularly in Asia – and still remains an anti-nuclear zealot – is no friend of the earth.

I believe it is time to stop being timid about declaring the benefits nuclear power has brought – and continues to bring – to this country.

- That since 1971, nuclear power in Canada has averted the atmospheric release of more than 10.5 million tons of acid gas and 900 millions tons of CO2.
- That nuclear power saves the country $1 billion per year in foreign exchange.
- That our industry will contribute $31 billion to Canada's GDP over the next five years.
- That we provide 26,000 jobs directly – and that, for example, the China sale alone will support 27,000 person years of employment in Canada
- That this year, we will provide $700 million in tax revenues to Canadian governments.
- That in many areas of science, engineering and electronics, the nuclear industry helps Canada remain at the leading edge of the new economy.
- That, in 1995 in Ontario, the cost of nuclear electricity was about 25 per cent lower than that derived from fossil fuels.

In addition, the Canadian nuclear industry – through the development of Cobalt 60 cancer treatment – is extending the lives of thousands of Canadians and millions of people around the world. It also brings major health benefits ranging from the sterilization of medical instruments through to effective diagnostic techniques.

It is the future of responsible energy policy that makes me optimistic about the future of nuclear power.

Any rational analysis would conclude that the interest of both the developing and developed world in nuclear power is like to increase, not decrease, in the future.

It is projected that to keep pace with population and economic growth, world energy supplies will have to double over the next 50 years. In the Asia-Pacific region alone, electricity supplies over the next 15 years will have to increase by double today's total installed global nuclear capacity. Many of the most obvious sites for hydroelectric power have been exploited. Alternative energy sources are not economical. Fossil fuels are being depleted and the environmental consequences of acid rain and global warming are becoming clearer day by day.

Domestic demand of electricity in Canada and other western countries should pick up within the decade, if one has any confidence whatsoever in our economic future. The fact is, I believe that 50 years hence, when historians look back on the experience of the past 10 or 15 years, they will see it as the exception, not the rule, a pause not a permanent state of affairs.

Every indicator suggests that the next century can be – and should be – the nuclear century. The question for us, is, will it also be the Canadian nuclear century. The answer will depend, in large part, on whether decisions taken are governed by emotion or reason.

I want to conclude, on the issue of responsibility. Reason will not carry the day if we do not do our part to educate, to participate, to speak out strongly and soundly about the business we are in.

It is not enough to quietly bid and accept contracts. It is not enough to reap the rewards and maintain a studied silence. It is not enough to simply talk to each other, the converted, and pretend that this constitutes public debate.

And, quite frankly, it is not enough to leave it to AECL and the CNA – not to mention the CNS.

I would hope that all of us would feel it a matter of responsibility to spend a portion of our time involved in public debate equivalent to the portion of our business that derives from the nuclear industry.

The Canadian Nuclear Workers Council should be commended for its efforts in educating the public. Some people in labour understand what the nuclear industry means in terms of good jobs. Those people are ready to put themselves on the line and speak out. I suggest the rest of us show willingness to do the same.

Not long ago, Hans Blix, the Director General of the International Atomic Energy Agency, raised an interesting thought. In terms of achieving active public support of nuclear energy's central role in a responsible treatment of our global environment, he commented that each year the nuclear industry continues to operate safely is one year closer to solving the environmental problems associated with the greenhouse effect. The scales will eventually tip toward nuclear as the only viable, environmentally sound, alternative to fossil fuels for baseload generation.

That comment frames our opportunity – and our challenge.

Will we meet it? I believe we must. And I believe we can.

CNA/CNS Annual Conference

Radiation Renaissance: Beyond Faust, Frankenstein and Fate

by Margaret Maxey

Ed.Note: *Dr. Margaret Maxey, who is a member of a Roman Catholic order as well as being professor of biomedical engineering at the University of Texas at Austin, was the invited speaker at the CNS luncheon during the CNA/CNS Annual Conference in Toronto, 8-111 June 1997. Following is a condensed version of Dr. Maxey's formal talk. She preceded her address with a number of stories and anecdotes that amused and surprised the audience.*

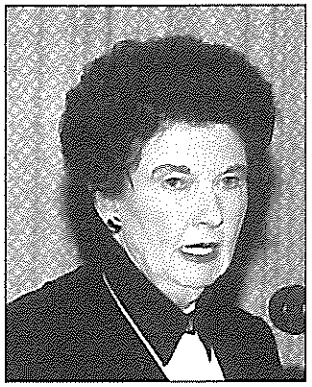
The most promising and powerful indication that a "radiation renaissance" revitalizing the nuclear energy option may be imminent is the slow but steady march of genuine scientific research committed to re-examining the validity of the Linear No-Threshold hypothesis (LNT) as the basis for regulations that purport to protect public health.

Serious scientific studies in the United State, canada, China, Sweden and Poland have yield credible evidence for the hypothesis of **hormesis**, namely that there is a net beneficial effect from low levels of exposure to otherwise toxic substances – in this case low-level radiation exposures.

It is quite another matter to overcome deeply ingrained public perceptions that, over two centuries, have been fueled by metaphors and symbols expressing alienation and disillusionment about technology in general, and nuclear technologies in particular. For 200 years, the symbolic figure of Faust has been a recurring literary image dramatizing the reprehensible proclivities inherent in "technological man."

Human ambivalence toward technology has also been given powerful literary coinage by the image of **FRANKENSTEIN**, the tale of a scientist whose quest for the power to tame nature's secrets leads him to bring an artificial being to life. Frankenstein realizes too late that he has created this monster, only to discover that his shortsighted failure to anticipate its social requirements leaves him totally helpless.

Ever since the birth of the scientific method, heightened expectations of the power of scientific reason to subdue the dangers of living in a natural world have been the driving force behind technological innovations. In a world now dominated by nuclear fear, these comforting assumptions have been overtaken by a profound reversal of values.



Dr. Margaret Maxey

The images of Faust and Frankenstein are invoked to warn us against an impending doom at our own hands. We are repeatedly warned that their fate will be our destiny if we humans do not reform our rising expectations and return to living lives of voluntary simplicity and self-abnegation in closer harmony with a pristine Nature formed by the Creator's hand.

Influential critics now insist that the tide of technological progress has been predestined from the outset to become unsustainable against the limits of Nature. 'Sustainability' now functions in our lexicon as a touchstone of orthodoxy and political correctness.

As the nuclear debate has unfolded, it would be a profound mistake to assume that the anti-nuclear movement has been about nuclear energy and weapons. Energy resources in general, and nuclear electricity in particular, have only been the surrogate and lightning rod for attracting forces given by a wholesale rejection of industrialized society.

The movement's most powerful strategy has been a related assumption, namely that the LNT theory is necessary to protect human health and safety. As a matter of self-preservation, a regulatory bureaucracy has institutionalized a pattern of "regulatory ratcheting" – continuously tightening and never loosening its grip by enacting "zero-risk" regulations. Consequently the goal of serving "the public interest" has become subservient to the goal of pacifying a narrow set of special interests.

This state of affairs invites us to examine more closely the assumptions which undergird the deep seated conflicts between opposing views of the World and Nature.

1. Worlds in Conflict Over "Sustainability"

Advocates of the nuclear option would gain valuable insights from a recent book, **CENTURY'S END.** Hillel Schwartz has amassed evidence of a phenomenon recurring at least since the end of the first millennium. As a society approaches the end of a century, from its ranks emerge all manner of prophecies of doom and destruction at our own hands. The 1790s bequeathed to the future the dire predictions of Nostradamus. In the 1890s, the War of the Currents between Edison and Westinghouse pitted DC against AC with long-term adverse consequences obstructing the dissemination of electricity and its beneficial effects for human well-being. In the 1990s, we are witnessing what can be called "The War of the Worlds." It has pit the World of the Catastrophist against the World of the Cornucopian.

The World of the Catastrophist appears pregnant with enormous problems. 'Limits to growth' slogans of the '70s have been displaced in the '90s by the more palatable language of *Sustainability* as a policy recommended to forestall the impending destruction of our only habitable planet. The Rio Declaration of June 1992 has announced to the world that, although energy is essential to human well-being, its production and consumption in wealthy industrialized nations is *unsustainable.* A complete overhaul of energy systems is prescribed. Agenda 21 calls for the rapid replacement of fossil fuels, nuclear plants, and large hydroelectric projects with so-called *renewable* energy sources, augmented by coercive regulations to force conservation and limit consumption demands.

Preconceptions

Four preconceptions undergird the altar of *sustainability.* A fundamental assumption holds that Nature exists in a fragile, precarious balance, and its ecosystemic harmonies must be protected from the rapacious encroachments of technological man. Consequently Earth has a finite "carrying capacity" assumed to be measurable in terms of a fixed quantifiable limit. This assumption dictates the belief that *growth has its fixed and finite limits* in population, resource usage and absorptive capacities. A correlative claim is that modern *technology* now has the *power to cause global destruction.* Close related to this assumption is the dictum of Rachel Carson's **SILENT SPRING:** "Man alone of all living forms creates cancer-causing agents." A fourth influential preconception is the one-molecule/one-hit theory, enshrined in the linear, zero-threshold hypothesis: *there is no safe dose* of exposure. The only safe dose is zero.

Once the World of the Catastrophist has taken hold of public perception, it is a small, logical step to join the crusade to displace an old anthropocentric *Ethic of Social Consequences* – the greatest good for the greatest number – with a biocentric *Environmental Ethic* which claims to derive its norms from ecosystemic harmonies easily discerned in a natural environment.

When we are tempted to believe that the industrialization of our society since the end of the 18th century has progressively imperiled human health and public safety, and that the quality of our environment has been ruined by industrial pollutants and hazardous wastes, we would do well to ponder the historical record preserved in Otto Bettmann's book, **THE GOOD OLD DAYS: THEY WERE TERRIBLE.** His pictorial record is worth a thousand words.

Sustainability Re-Evaluated

If our energy choices are to be justified as *ethical choices,* equal time must be accorded to the world-view diametrically opposed to the World of the Catastrophist – namely, the *World of the Cornucopian.* Cornucopians are also known as Advocates of Technological Substitutability who maintain that a Catastrophist view of Sustainability is not only a self-fulfilling prophecy but scientifically bankrupt and ethically reprehensible in its social consequences.

Ironically Catastrophist preconceptions about Sustainability had been anticipated and persuasively rebutted in 1962 by Barbara Ward (Lady Jackson) in a brief book entitled **THE RICH NATIONS AND THE POOR NATIONS.** Her opposing position was three-fold. First, when poverty diminishes, population growth slows in the wake of a demographic transition. Second, empowering Third World nations to pursue their own development increases world trade, thereby helping Western economies as well. Third, she maintains that it is mere wishful thinking to predict that further progress leads unavoidably to world disaster.

Barbara Ward's analysis of the demographic transition that occurs when people's standard of living improves has been understandably ignored or rejected by a neo-Malthusian Catastrophist doctrine of sustainability.

In a Cornucopian world-view, true protection of people and their environment is compellingly expressed by Dennis Avery in his essay, "Poverty Won't Save the Planet": "The whole world has to become affluent... The only way to save both people and the environment is by extending affluence and discovering better technologies and production systems." Max Singer's **PASSAGE TO A HUMAN WORLD** points out that the human species has lived in a natural world 'close to Nature' for 10,000 years. Thomas Hobbes long ago

stated the facts of the matter: "A life lived in a state of Nature is solitary, poor, nasty, brutish and short."

For a Cornucopian world-view, development (not mindless growth) is a necessity if equity and intergenerational justice are to exist. We have lost the distinction between raw materials buried in the Earth's crust, and resources, the ultimate origin of which is the human mind's ingenuity.

The most misunderstood, hence perniciously subversive concept today is that of **wealth**. Contrary to popular belief, it is not some hidden 'motherlode' which needs only to be uncovered, mined, and then 'distributed' throughout a meritorious population. Wealth must be generated, created, and sustained by technological creativity transforming raw materials into resources.

When we enter the twenty-first century, we shall be entering a world different from the twentieth with all its upheavals and conflicts. But we shall still have to wrestle with the tyranny of safety. The insurgence of a broad risk-assessment movement has not reassured or allayed public fears, but instead inflated feelings of apprehension and dread.

II. Environmental Ethics and Nuclear Fears

In the interest of fairness, and in pursuit of the safety and health of nations, let us tentatively adopt the premise proposed by a new Environmental Ethic, namely that Nature's uniformities, processes and "laws" should provide us with norms for ethical reasoning.

If citizens were required to comprehend the magnitude of **ENVIRONMENTAL RADIOACTIVITY** thoroughly researched by Merrill Eisenbud, and the wide variations in natural background radiation to which humans have been exposed throughout history, logic would compel the conclusion that exposures to man-made sources of radiation in medical diagnostics and electricity generation are in fact not only trivial by comparison, but have produced unprecedented benefits for human health and well being. In the United States, more than ten million medical diagnostics using nuclear-based procedures are conducted annually, plus 30,000 therapeutic treatments. Sterilization of medical materials are widespread. Disinfection of sewage and irradiation of food could be commonplace were it not for phobic fears.

T.D. Luckey's research published in **HOMESIS WITH IONIZING RADIATION** has amassed evidence of his thesis, namely, that there is a net beneficial effect from low levels of exposure to otherwise toxic substances. Human health depends upon the presence of selenium, copper, fluoride, potassium 40, carbon 14, and even nickel in our bodies – substances that in large doses would be lethal.

In pursuit of honesty, Nature-as-ethically-normative compels us to realize that the incorporation of radioactive waste by-products into the earth's crust does not constitute a 'contamination' of an otherwise pristine environment. Alleged dangers resulting from geological disposal of radwastes have been predicated on the potential for dissolution and transport of radioactivity in water. However, many **naturally occurring toxic elements in the earth's crust** are continuously leaching into water supplies and the food chain.

If our entire electrical supply for 100 years were derived from nuclear fission, and all the wastes resulting from it were buried, the existing toxicity of the earth's crust would be increased by one ten-millionth of one percent (1/10,000,000 of 1%).

An objection contends that such a comparison is invalid because wastes would be concentrated within a few repositories, whereas earth's toxic elements are distributed more uniformly. Nature has likewise concentrated toxic minerals into ore bodies.

Toxicity does not determine hazard. The mere existence of a toxic substance in the biosphere is no justification for a moral claim about its unacceptability. The only sound basis for judging the ethical significance of any toxic substance in the biosphere – including nuclear technologies for medicine or energy or agriculture – is the likelihood of exposure and assimilation of a harmful dose at a rate detrimental to people and other valued organisms.

The fundamental point at issue is this: the magnitude of risks posed by Nature ought to be compared and contrasted with the risks posed by human technologies in general, and by nuclear technologies in particular.

The popular image of Nature existing as a benevolent, tranquil, and safe haven – posed in a fragile, precarious balance – quickly dissipates when one is required to compare the magnitude of potential dangers inflicted by Nature on humans – by floods, tornadoes, earthquakes, volcanic eruptions, tsunamis – in contrast to potential dangers posed by modern technologies. Nature-as-Victim becomes transformed into Nature-as-Culprit.

The fundamental ethical principle of equitable protection – i.e. the allocation of limited amounts of public revenues proportionally – requires regulators to make a necessary comparison of more or less cost-effective methods of reducing **certifiable** dangers, prior to spending billions of tax dollars to eliminate **hypothetical** threats to public health and safety, whether the source is "natural" or "man-made". The question, "How safe is safe enough?" is not ethically adequate. The moral

question should be "How **fair** is safe enough?"

When a history of the 1990s is written, what now appears opaque is destined to become transparent. The general public has yet to comprehend the benefits to public health and safety derived from nuclear-generated electricity or medicine or agricultural applications. The dismantling of nuclear weapons and the conversion of their destructive power into the benign source of power to generate electricity for human benefit represents a formidable test of human resolve.

The true effects of apocalyptic thinking so widespread today have yet to be demonstrated. A 'better safe than sorry' attitude may not prove to be an innocent gamble, but instead, an attitude smasher leading to the 'hopelessness-helplessness-syndrome' identified by Dr. Leonard Sagan in his book, **THE HEALTH OF NATIONS.**

Advocates of a new Environmental Ethic have assumed that raw Nature is the source of justice interpreted as "biocentric equality". Hence they regard modern technological powers – in particular the powers unleashed by atomic fission – as profane violations of ecosystemic harmonies. By championing "biocentric equality", advocates of an Environmental Ethic presume that they are pursuing a superior logic that accords rights to Nature on a par with the inalienable rights of human individuals. The opposite is the case. A veneration of raw Nature as virtually sacred and untouchable betrays the substitution of neo-pagan romanticism, cloaked as secular religiosity, for an understanding of Nature as an ongoing creation of human beings, for the sake of human beings.

Before celebrating the birth of a new Environmental Ethic requiring us to conform human activities to presumably "sustainable ecosystemic harmonies", we should be wise enough to realize that such an ethic dies the death of a thousand qualifications.

COG / IAEA Workshop

Managing Nuclear Safety at CANDU Plants

An innovative Workshop that brought together representatives from all countries operating or building CANDU nuclear power plants was held in Toronto from Aril 28 to May , 1997. Officially titled the COG/IAEA International Workshop on: "Managing Nuclear Safety at CANDU (PHWR) Plants", it was organized and hosted by the CANDU Owners Group and co-sponsored by the International Atomic Energy Agency. The three day gathering involved 40 delegates, from Argentina, China, India, Korea, Pakistan and Romania, as well as from the three Canadian nuclear utilities and Atomic Energy of Canada Limited

The objectives of the Workshop were to:

- provide a forum for nuclear safety managers
- share information on operating approaches
- identify issues of mutual interest, and
- define follow-up activities

The Workshop sessions dealt with:

- national perspectives on managing nuclear safety
- nuclear safety issues of common interest
- common themes in CANDU safety management

Following welcoming remarks by **Bryan Murdoch**, representing COG, and **Dr. Jamshed Hasmi** of the IAEA, **Dr. Jatin Nathwani**, manager of COG's Safety and Licensing programs, outlined the objectives of, and arrangements for, the Workshop, and introduced the lead-off speaker **Ken Talbot**, vice-president Pickering NGS.

Talbot began his talk on the turn around of Pickering by commenting that, "Pickering is the largest nuclear power station under one rood, and that roof leaks." He reviewed the history of the Pickering station which as built in two phases, Pickering A with start-up between 1971 and 1973, and Pickering B, 1982 to 1986. Both plants operated well for about the first 14 years. As Talbot put it, good technology appears to drive CANDUs for the first 14 years but then operation declines because of poor management and poor maintenance. A failure of an emergency coolant injection valve in 1995 finally alerted management and all eight units were shut down. Six have now been restarted.

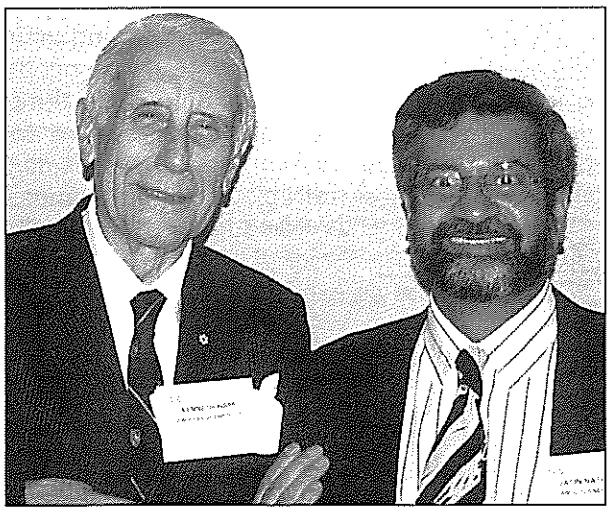
"The technology did not fail, we failed it" Talbot stated. He noted that "high-level" indicators, such as gross safety system availability, or radioactive releases, are not sufficient. It is necessary, he said, to develop and use many more "low level" indicators of system and equipment performance.

The balance of the first day was devoted to reports from all of the utilities represented.

Bong-Seob Han, from the Kore Electric Power Company (KEPCO) commented that they had developed low level performance indicators covering 252 items.(which, he said later, they would be willing to make available). KEPCO has a lifetime management plan. Wolsong 1, the CANDU flagship in Korea, has had an IAEA OSART inspection and a WANO peer review.

John Paciga, from New Brunswick Power, expressed concern that Point Lepreau G.S., which had an 85% lifetime capacity factor, might be following the Pickering pattern given the number of problems in the last couple of years. It has been recognized that operational management and human performance need to be improved. They now have a strategic plan with goals, measures and targets; a design assurance program, configuration assurance program, improvements in root cause analysis, etc.

C. Suri Surendar, executive director, Nuclear Power Corporation India Ltd., gave a brief overview of the Indian nuclear power program



Dr. Kenneth Hare, guest speaker at the COG / IAEA Workshop held in Toronto the beginning of May, 1997, poses with Dr. Jatin Nathwani, organizer and co-chairman of the workshop.

which has an installed capacity of 1840 MW(e)(mostly from 200 MW(e) plants based on the Douglas Point design). NPCIL does two inspections of each plant each year in addition to those by the regulatory board. An internal safety review, based on INPO, WANO and ASCOT systems is conducted every four years. He commented that the utility, regulator and research organizations work as a team. Many modifications have ben made and are being made to overcome ageing. NPCIL is aware of and sensitive to the "14 year trough" noted by Ken Talbot.

Dan Austman gave a perspective from Ontario Hydro's Bruce B plant. A re-organization is underway, to be completed by 1999. He reviewed the fuel relocation and power pulse problem that had resulted in the Bruce plants being derated. Bruce A has chosen to change the fueling method to fuel with the coolant flow, while Bruce B has chosen to use longer bundles to reduce the gap at the end of the string.

Mazher Hasan, deputy manager of the Kanupp plant in Pakistan, outlined the safety organization in his country. Kanupp has a long-term safety review every 10 years which focuses on ageing. There are quarterly regulatory inspections, annual reviews, event based reviews. Two IAEA OSART missions have been held and a WANO peer review. He expressed the view that when faced with the question of applying new safety criteria to an old plant, there is a need for a backfit policy.

Gu Jun, from the China Atomic Energy Authority and deputy director of Qinshan 3 reviewed the national perspective for nuclear power in China. Because Qinshan is the first nuclear power plant in China no domestic training was available so staff were sent overseas and foreign experts were invited. Although some modifications of the plant had already been made it had achieved a capacity factor of 84% over the past two years.

Horacio Rapoport, nuclear safety manager for Nucleoelectrica Argentina, commented that they were taking actions to meet the obligations of the Nuclear Safety Convention. These include: improved organization; WANO peer review at Embalse, application of PSA at Atucha; involvement of IAEA OSART teams. He noted that Argentina's adoption of ICRP 60, with its lower recommended dose limits, was causing some difficulties.

Marc Petrilli, from Gentilly 2, presented a further Canadian perspective, noting the somewhat unusual organization of nuclear within Hydro Quebec with the G-2 plant manager and the nuclear safety manager both reporting directly to the Director of Nuclear and Thermal. He outlined the safety approach at G-2 which includes: definition of a safe operating envelope; emphasis on configuration management; review of the Safety Analysis Report every three years; continuous updating of emergency procedures.

Marian Serban, technical director at Cernavoda 1 in Romania, described their national and local context. They are emphasizing human factors since the staff is very knowledgeable technically. He commented that the licensing framework, which has embedded much of the USNRC prescriptive approach, is not suitable for CANDU. In this context he commented that a problem was the inconsistency of Operating Policies and Procedures among CANDU stations.

Alastair Smith, manager of nuclear safety at the Pickering NGS, was the last presenter in the session on "National Perspectives". He noted the change made in their process for Significant Event Reports. There are now four categories. This has encouraged more reports but most now are in the lesser significant categories.

In attempting to summarize the day's presentations, session chairman, Jatin Nathwani, identified the following primary concerns:

- indicators of safety performance
- configuration management
- backfit policies
- safety culture
- safety analysis tools
- safe operating envelopes and OP&Ps
- plant ageing

At the Workshop dinner the first evening **Dr. Kenneth Hare** was the guest speaker. Dr Hare was Chairman of the Ontario Nuclear Safety Review which was established in the late 1980s after the Chernobyl accident and is currently a member (and former chairman) of Ontario Hydro's Technical Advisory Panel on Nuclear Safety. He noted that he first became involved in nuclear affairs as a member of a special panel in the late 1970s to examine geologic disposal of nuclear waste. He commented that he still believes in that approach. Nuclear energy is essential, he stated, if we are to meet commitments to reduce "greenhouse" gases. While no one has been killed in Canad from nuclear activities he said that he was aware of at least five Ontario Hydro nuclear workers who had died in traffic accidents commuting to work.

The following morning was devoted to presentations on "Nuclear Safety Issues of Common Interest".

Nina Oliva of Ontario Hydro gave a paper on the topic of Safe Operating Envelope which he defined as "the outer bound of plant conditions within which day-to-day plant operation must be maintained in order to comply with regulatory requirements, assocaited safe design criteria and corporate muclear safety goals". He noted that

different approaches were being studied.

Paul Thompson of NB Power and Marc Petrilli of Hydro Quebec shared the topic of Ageing.and emphasized the need for an overall ageing and maintenance plan covering all aspects of the plant. Follow of "warning signs" is important.

Yong-Mann Song from the Korea Atomic Energy Research Institute presented the results of an analysis of an extreme loss-of-coolant accident with no emergency coolant, no moderator cooling, no shield tank cooling which predicted containment failure.

During that afternoon and the first part of the third morning the delegates broke into two discussion groups; one on "operations" the other on "design and analysis" both under the broad heading of "Common Themes in CANDU Safety". The results of these discussion were reported back by the group leaders, Paul Thompson and John Luxat This was followed by a session in which topics were assigned priorities and follow-up activities were identified.

High priority topics were:

- safe operating envelope and Operating Policies and Principles
- plan for management of plant ageing
- safety performance indicators
- integrated probabilistic safety assessment
- PHWR safety analysis tools
- risk based decision making and priorization.

Actions and timetables were established for each items. COG will be the central focal point for dissemination of reports.

The techncial program committee for the workshop consisted of Jatin Nathwani, John Luxat and Visotr Snell, all associated with COG, and Jamshed Hasmi of the IAEA. The arrangements for this very well-run meeting were made by Judy Graham and associates from the COG office.

Call for Abstracts

20th CNS Nuclear Simulation Symposium

Niagara-on-the-Lake, Ontario
September 7 - 9, 1997

The scope of the Symposium covers all aspects of nuclear modeling and simulation. The main objective is to provide a forum for discussion and exchange of views among scientists and engineers in the nuclear industry

Papers will be presented on topics in the following areas:

- reactor physics, including fuel management and advanced fuel cycles
- system and sub-channel thermalhydraulics
- safety analysis methods including code uncertainty
- computer code validation

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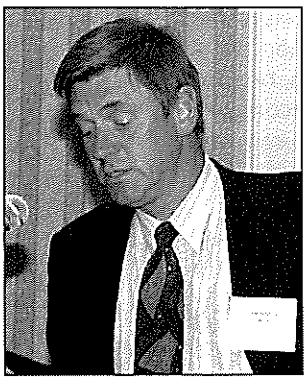
COG Safety and Licensing Seminar

The annual seminar to review the research and development being conducted under the Safety and Licensing program of the CANDU Owners Group was held in Toronto, May 27 - 29, 1997, with approximately 150 registrants.

Following the pattern of recent years the first afternoon was devoted to "plenary" sessions with overviews and an open discussion on the total program.



Jim Harvie

Dr. Jatin Nathwani, manager of the COG Safety and Licensing program, opened the seminar with summaries of; the COG organization, the agreement between COG and the Atomic Energy Control Board, and the COG Safety and Licensing Program. Nathwani noted that the rationale for the program includes safety, protection of investment, and licensing.

Reflecting an overall 10% reduction in the COG research and development budget, the COG S & L budget for 1997-98 will be $26.2 M, down from $28.7 M last year and $37.0 M in 1995 - 96. Nathwani noted that some related projects will be directly funded by Atomic Energy of Canada Limited.

On the international front he mentioned: the first meeting of an International Working Group Meeting on Advanced Technology of Heavy Water Reactors organized by the International Atomic Energy Agency which was held in June 1996; a related nuclear safety meeting in Rome in October 1996 and a follow-up one in Argentina in April 1997. A special meeting on hydrogen is scheduled for Toronto at the end of June 1997.

Information exchange under the COG - AECB Agreement continued to work well with three formal meetings, a number of informal contacts and a number of reports submitted.

Nathwani commented that COG has an Internet site but noted that a password is needed to access proprietary information. The COG Website is: https://www/cognet.org/

John Luxat, of Ontario Hydro and a member of the COG Safety and Licensing Directing committee, provided an overview of the following "strategic plan issues" identified for the S & L program. Three developments over the past year have influenced the views on research and development , he stated, the emphasis on regaining operation excellence by the nuclear utilities; the initiative on a matrix for code validation; and the initiative to develop a standard "toolset".

The "strategic plan issues" are:

- coolant void positive reactivity
- effectiveness of ECCS
- core cooling in the absence of forced flow
- hydrogen behaviour in containment
- post-accident filter effectiveness
- consequence of pressure tube failure
- behaviour of fuel and fuel channels at high temperature
- fission product release and transport and aerosol behaviour
- effect of ageing on accident consequences
- trip effectiveness criteria and post-dryout behaviour
- molten fuel - moderator interactions
- technical integration of R & D results in safety analysis
- maintain and improve reliability, economics and safety of CANDU fuel

He acknowledged later that many of these were identical to the AECB's "generic" issues

Reports on the work related to these issues made up the agenda for the remaining two days of the seminar.

Len Simpson, Director of Safety Research at AECL, spoke on the related work being carried out by AECL on its own account. This includes topics of interest to the Korean regulatory agency associated with extreme accidents and source terms, as well as work to maintain the company's capabilities. Among the topics mentioned were:

- retention of molten fuel in the calandria
- experiments in support of the LICIRC containment code
- behaviour of fuel at high temperature
- critical fuel channel power
- dynamic fraction properties of ZrNb.

The final "plenary" speaker was **Jim Harvie**, Director General, Reactor Regulation, at the AECB,

who noted that this was his first time at the seminar although he had been regularly involved in earlier information exchange meetings. Harvie started out by observing that the Canadian nuclear power industry was in "sorry mess". He referred to the years of neglect at Pickering which resulted in equipment in poor condition and Point Lepreau "going from crisis to crisis".

Although early capacity factors were high, the safety culture, he opined, was "dreadful". In the mid 1970s, he noted, there was no facility to test the effectiveness of ECCS and quoted a senior AECL official of the day as saying that such a facility would "only raise more questions then it would answer". Things have improved, he acknowledged, noting the willingness of Ontario Hydro to shutdown entire stations such as Pickering. That would never have happened 15 years ago, he stated. The industry now recognizes its shortcomings, plants are being subjected to peer reviews and "Ontario Hydro has swallowed its pride and brought in outside experts".

Meanwhile, he said, the AECB has gone from "essentially a rubber stamp organization" to a "fairly independent regulatory agency", but, he acknowledged, "we have done a lousy job of managing [our] people to work together".

Turning to research, Harvie emphasized the importance of demonstrating safety for design based. CANDU is the only power reactor for which this has not been done. Researchers will not put themselves out of a job, he reassured the audience, since ageing reactors will bring many new problems. He expressed concern about the privatization of the Whiteshell Laboratories and the future of the RD14M facility in particular and about the only out-reactor fuel test facility being in private hands.

Harvie observed that the COG program appears to be drawn more the list of AECB generic issues than from a fundamental examination of topics of importance to safety. The responsibility for safety lies with the licensee, not the regulator, he reminded his audience. "We have an expensive safety research program that is not driven by any formal process", he asserted.

The Nuclear Safety Convention, to which Canada adheres, requires peer reviews of the overall system for safety, he noted. These will probably reveal many shortcomings, he suggested, but may "also reveal some strengths". On that note, and a further observation about the turn-around program at Ontario Hydro, Harvie concluded with the comment, "While we live in difficult times, I have guarded optimism for the future".

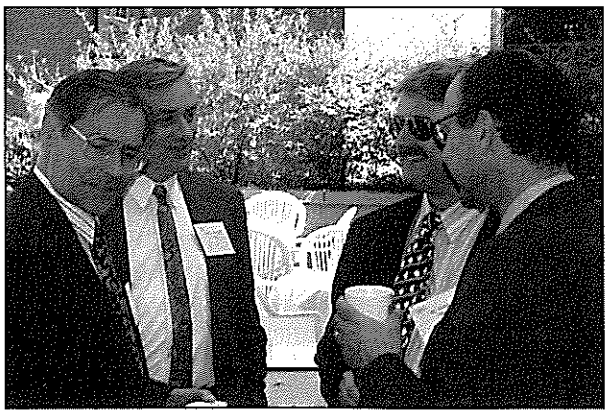
In the discussion session the question of the underlying philosophy for safety research and development came up. Marc Petrilli, of Hydro Quebec acknowledged that there is no formal priorization process. Victor Snell, from AECL, stated that they chose topics by consensus. John Luxat commented that the COG system was similar.

Aly Aly of the AECB, noting the declining COG budget, questioned the resolve of industry to maintain safety R & D. Nathwani commented that Harvie's reminder of the licensee responsibility is helpful while other COG representatives expressed their personal belief that the utilities will continue to support the program. Len Simpson expressed concern about the future of the hot cells at the Whiteshell Laboratories.

Turning to the future, a question was raised who would look after [safety R & D] in 20 years or more. Victor Snell and Len Simpson suggested that if the nuclear program remains active it will attract good people who will carry on the work, but no one had an answer about future funding.

The following two days of the seminar were devoted to detailed accounts of the work related to the "strategic issues" listed by John Luxat.

Further information on the COG Safety and Licensing Seminar or program can be obtained from Dr. Jatin Nathwani, who is located at Ontario Hydro, tel. 416-592-5266; FAX 416-592-5276; e-mail: nathwanij@hydro,on.ca



John Waddington (L) and Aly Aly (R) of the AECB chat with Ontario Hydro's Keith Weaver andRic Fluke during a break in the COG Safety and Licensing Seminar held in Toronto the end of May, 1997

1997 Student Conference

by Lisa Lang

Lisa Lang

Ed. Note: *the following is a slightly edited version of a report by Lisa Lang, a graduate student at the University of New Brunswick, on the 1997 CNS/CNA Student conference. Lisa was also the chairperson of the successful conference.*

The 22nd CNA/CNS Annual Student Conference was held at the Wu Conference Centre at the University of New Brunswick, Fredericton, NB on March 14 - 15, 1997. It was hosted by the Chemical Engineering Department. Approximately forty individuals (students, professors, and industry professionals) attended this event. A total of eighteen out of the twenty - two papers submitted were presented which have been compiled in a bound conference proceedings *(which are available from the organizers or the CNS office).*

In addition to the technical sessions, the Conference included a technical tour, an invited talk, and a banquet The Technical Tour of Point Lepreau Nuclear Generating Station was organized, with the help of Kathleen Duguay, for Thursday, March 13, 1997. Six students participated in this tour and they found it to be very interesting and informative.

The Invited Talk was given at the opening of the conference by Dr. Krish Krishnan, the Chair of the Nuclear Science & Engineering Division of the Canadian Nuclear Society. He discussed CNS activities along with the status of nuclear activities in Canada. The banquet was held on the evening of March 14, 1997 in conjunction with the annual dinner of the CNS New Brunswick Branch. Dr. Frank Wilson, Chairman of New Brunswick Power Corporation and Vice - President of Research and International Co - Operation at the University of New Brunswick, was the guest speaker for this event. The title of his talk was "Nuclear's Contribution to the Energy Sector - Current and Future Challenges."

Awards

The judging committee consisted of three individuals:

- Dr. Guido Bendrich - University of New Brunswick
- Mrs. Guylaine Goszczynski - Centre for Nuclear Energy Research
- Mr. Jack Walsworth - Atlantic Nuclear Incorporated

The task of selecting the award winners was difficult since all the presentation were of high calibre. Awards were presented at the end of the conference for the Best Communication which included the technical content as well as the quality of the presentation. (Ed. Note: This was a departure from the practice of recent years when awards were made in three categories, undergraduate, master's, and doctorate) The first place prize consisted of a cheque and a software package from Corel Corporation, the second prize consisted of a cheque and a software package from Corel Corporation, and the third prize consisted of a cheque. The awards were given to the following presenters:

First Prize:
David Novog - McMaster University

Second Prize:
Michael Beshara - University of New Brunswick

Third Prize:
Ottman El hajjaji - École Polytechnique

Honourable Mention:
Marc Basset - University of New Brunswick

A summary of the sessions, based on each presenter's abstract, is given below.

Session 1: Materials

Chairperson: Dr. Derek Lister
University of New Brunswick

Six papers were presented in the Materials Session. Danny Pagé, a graduate student of the Royal Military College of Canada, began the conference by discussing his work on the ***Effects of neutron and gamma radiation on the viscous behavior of semi-crystalline polyetheretherketone (PEEK).*** An attempt was made to show that PEEK is among one of the most promising polymeric materials for nuclear applications by looking at its resistance to radiation, mechanical properties, and chemical stability. It was concluded that there is a gain in understanding the mechanical performance of PEEK in radiation environments, that tools made of PEEK could be used in nuclear reactors for long periods of time, and that PEEK could be used to build containers for the transport of nuclear waste fuel.

Brian Corse, a graduate student of the Royal Military College of Canada continued the session by discussing ***FORM 2.0: Fuel oxidation and release model.*** This topic shows a means of quantifying the release of fission products in the case of an accident and to determine the dominant chemical form of release to assess its hazard to the public.

The third paper, by Marc Basset, a graduate student of the University of New Brunswick was presented on ***Magnetite Deposition on Alloy - 800 CANDU - 6 Boiler Tubes.*** His presentation discussed the deposition of col-

loidal magnetite particles (regular sized (< 1_m) and shaped particles which are synthesized in the lab). The mechanisms associated with deposition, the transport and attachment steps, were also explained along with the factors which enhance or impede deposition. Mr. Basset received Honourable Mention for his excellent presentation.

Tutun Nugraha, a graduate student of the University of Toronto, presented the fourth paper on ***A Study of the Performance of Radioiodine Sampling Lines Under Accident Conditions.*** The deposition rate of iodine under various operating conditions (iodine gas phase concentration, tube surface temperature, and relative humidity) was observed. Two types of steel were used, SS - 304L and SS - 316L, in attempt to assess the performance of the currently existing gaseous radioiodine sampling line in CANDU reactors. Mr. Nugraha's results showed that the iodine deposition rate was initially high and decreased as time passed. In some cases, surface saturation was observed during which no further iodine accumulation occurred.

Yin Wong, a graduate student of the University of Toronto presented her work on the ***Degradation effect of LiOH/F- solution on ZrO_2.*** LiOH is added to the reactor coolant to control the corrosion of the steel circuit but a detrimental effect of the LiOH/fluoride solution on the corrosion resistance was observed. It was found that oxidation excursions in LiOH/F- solution under H_2 overpressure are caused by the degradation of the protective ZrO_2 film via a dissolution and redeposition process. A recommendation to analyze oxides from reactor cladding for F- was made.

The final paper was presented by Michael Beshara, an undergraduate student of the University of New Brunswick. His talk was entitled ***Accelerated Wall Thinning of CANDU Outlet Feeders.*** The premature thinning of CANDU - 6 outlet feeders was mathematically modeled by empirical correlation of time averaged two phase flow velocity and ultrasonic thickness measurements performed at Point Lepreau Nuclear Generating Station. The resultant equation was compared to inspection results obtained from another CANDU plant of similar design. The results were found to be in good agreement with the PLNGS model. If the rate of flow - assisted corrosion cannot be reduced, replacement of some feeders may be required before the designed lifetime of each plant. Mr. Beshara won second prize for his excellent presentation.

Session 2: Thermalhydraulics

Chairperson: **Dr. Robin Chaplin**
University of New Brunswick

Michael Campbell, a graduate student of Carleton University presented the first paper in this session. He discussed ***Experimental and analytical study of CANDU passive containments during loss of coolant accidents.*** The experimental apparatus used in the Slowpoke study has been modified to simulate all the important thermalhydraulic processes present in a passive containment during a LOCA. The apparatus and PASSCON program were in the commissioning stage and no results were available at the time of the presentation.

The last paper was presented by Alex Kwan, a graduate student of McMaster University. The topic of his talk was ***Simulation of a larger scale non - manifold header model for the CANDU nuclear reactor primary heat transport system.*** NUCIRC is a one - dimensional steady - state code that provides a detailed representation of the entire CANDU primary heat transport system (PHTS). Two reactor header models are currently employed by NUCIRC, the non - manifold and the manifold model. The non - manifold model simulates the headers as constant pressure reservoirs, while the manifold model simulates the axial pressure gradients in the headers and therefore provides more accurate estimates. His presentation demonstrated the ability of the non - manifold header model to simulate the larger scale CANDU headers.

Session 3: Radiation Processing

Chairperson: **Mr. Neil Craik**
Atomic Energy of Canada Limited

The first paper was presented by Hassan Jama, a graduate student of the University of New Brunswick. He discussed ***Detection of Debonding of Composite - Aluminum Joints Using Gamma - ray Compton Scattering.*** A gamma - ray Compton scattering technique for the detection of collinear flaws and the determination of their location and size was developed. A collimated narrow beam of monochromatic photons is made incident on the structure and Compton - scattered photons are detected. The energy of the measured radiation is selected so that it detects photons scattered at the designated location of the adhesive material. The width of the detected peak was related to the size of the flaw.

David Novog, a graduate student of McMaster University presented the last paper on ***Real Time Neutron Radiography of Boiling Refrigerant 134a Under Smooth- and Swirl- Flow Conditions.*** Mr. Novog won the first prize for his excellent presentation. He investigated the instantaneous void fraction, elongated bubble length, and propagation velocity for refrigerant 134a by real time neutron radiography (RTNR). It was found that for a mass flux of less than 15 kg/m2s , significant void is produced at a heat flux of 20 kW/m2 with predominantly elongated bubble flow. For a mass flux above this value, there was no significant void observed. For a mass flux below 15 kg/m2s, the cross sectional average void fraction decreased with increasing mass flux for a given heat flux.

Session 4: Nuclear Safety

Chairperson: **Mr. Paul Thompson**
New Brunswick Power Corporation

The first paper was presented by Captain D.J. Sims, a graduate student of the Royal Military College. The title of his talk was ***Gamma-Ray Spectroscopy Program for the Canadian Forces Nuclear Emergency Response Teams (NERTs).*** The objective of his research is to develop a system which will make gamma - ray spectroscopy employment in the Canadian Forces straightforward and will enable the NERTs to determine dose rates from sample activities. SCAAP, a computer program, was utilized to calculate the dose rate, treating the samples as one

would if it had been taken during a nuclear emergency using an air sampler. The values determined by SCAAP and those determined by manual calculation were found to be identical, indicating that the programming of SCAAP is valid.

Monica King, an undergraduate student of the University of New Brunswick, presented her work on ***CATHENA Simulation of a 35% Reactor Inlet Header Break at Point Lepreau Nuclear Generating Station.*** This two - phase flow thermalhydraulic code, Canadian Algorithm for THErmalhydraulic Network Analysis (CATHENA), was developed by Atomic Energy of Canada Limited. Ms. King simulated a 35% reactor inlet header break. The input data file models the logic (opening and closing of valves, special control systems, etc.) and the geometry (pipe and component dimension) of the PHTS of a typical CANDU 600 reactor. It has been shown that the code has predicted results comparable to what can be expected for this accident scenario.

An undergraduate student of the University of New Brunswick, Matthew Holmes, presented the third paper on ***Heat sinks monitoring during the 1995 maintenance outage at Point Lepreau Generating Station (PLGS).*** He discussed the philosophy behind heat sinks monitoring carried out by the operational safety group during the different stages of the 1995 outage at PLGS. An outline of the simple procedure for the analysis of the instrumentation signals of monitored process variables was included. The information in Mr. Holmes' report is applicable to heat sinks monitoring to be carried out in future maintenance outages.

The final paper was presented by Fariborz Taghipour, a graduate student of the University of Toronto. His presentation was entitled ***Radioiodine Behavior under Reactor Accident Conditions.*** His work involved understanding and predicting the rate and extent of iodine volatilization. This requires a reliable model of iodine behavior which can be tested against an experimental database. Mr. Taghipour discussed separate effect experiments performed to evaluate the impact of parameters affecting iodine volatility in an irradiated system for a range of possible conditions in a containment structure after an accident.

Session 5: Chemistry/Physics

Chairperson: Dr. Jocelyn Richer
Atomic Energy of Canada Limited

This session began with the paper presented by Franck Giraudeau, a graduate student of the University of New Brunswick, on the ***Measurement of Dissolved Hydrogen Fugacities and Henry's Law Constant for Simulated Pressurized Water Reactor (PWR) Solutions.*** The Henry's Law constants and the fugacities of dissolved hydrogen have been measured using a new method with a high temperature and high pressure palladium probe. Laboratory tests have been performed between 217°C and 308°C at 2250 psi. Results for pure - water and simulated PWR solutions have been compared. The effect of lithium hydroxide and boric oxide addition has also been studied for high concentrations (16,300 ppm lithium; 12,800 ppm boron) and can be explained by the well - known salting - in/salting - out phenomena.

The second paper, ***Data Analysis and Statistical Study of Quasi - Projectile Decay in $^{35}Cl + ^{197}Au$ Collisions at 30 MeV/nucleon***, was presented by Xin Bai, a graduate student of Université Laval. He discussed the experimental data of $^{35}Cl + ^{197}Au$ at 30MeV/nucleon with a multiplicity larger than 2 and the total charge detected equal to 17 on the basis of energy calibration and particle identification. The peripheral and semi - peripheral reaction products have been detected by the CRL - Laval array (3 telescopes, 48 phoswich detectors, and 32 CsI detectors). Excitation energy, velocity, and angular distributions have been reconstructed from its decay products. The decay into as many as 10 charged particles with as high as 8MeV/nucleon of excitation energy was observed.

Juliette Ling, a graduate student of the University of Toronto presented her work on ***The effect of chemical reaction on the mass transfer of iodine.*** Mass transfer coefficients for the absorption and evaporation of iodine from two solutions were determined experimentally and compared to values predicted from computer simulation. It was found that the errors in empirical K_{OL} values ranged from 10% to 25%. It was concluded that chemical reaction significantly increases K_{OL} and that the reaction with thiosulphate ions has a greater effect on K_{OL} than the reaction with iodide ions.

The final paper was presented on ***Calcul des coefficients de réactivité pour les effets séparés pour le réacteur Slowpoke - 2 de l'École Polytechnique*** by Ottman El hajjaji, a graduate student of l'École Polytechnique. His work involved calculating reactor coefficients for a new 20% LEU (Low Enrichment Uranium) core from a 93% HEU (High Enrichment Uranium) core. The core of the Slowpoke - 2 reactor of l'École Polytechnique is being replaced after 20 years of service. Mr. El hajjaji won the third prize for his excellent presentation.

Sponsorships

The following sponsors helped make the 22nd CNA/CNS Annual Student Conference a success:

- Atlantic Nuclear Services Limited
- Atomic Energy of Canada Limited
- Canadian Nuclear Association
- Canadian Nuclear Society
- Centre for Nuclear Energy Research
- Corel Corporation
- Natural Resources Canada
- Ontario Hydro
- Siemens Electric Limited

The organizers wish to thank the sponsors for their generous support.

GENERAL news

Book Launch

Just prior to the opening reception for the 1997 CNA/CNS Annual Conference at the Inn-on-the-Park Hotel in Toronto on June 8, 1997, a special ceremony was held to celebrate the publication of an important new book: **Canada Enters the Nuclear Age: A Technical History of Atomic Energy of Canada Limited as Seen From its Research Laboratories.**

With a fanfare of trumpets AECL president Reid Morden led a parade of 11 of the 16 authors into the reception room. Then AECL vice-president David Torgerson, acting as master of ceremonies, introduced AECL chairman Robert Nixon, Reid Morden and the authors and invited lead author Don Hurst to speak on behalf of the group. (Excerpts from Dr. Hurst's comments are presented below.)

Dr. Howard Rae, one of the principal authors of the history, presented copies of the 430 page book to Bob Nixon and Reid Morden. Morden thanked the authors for recording the important scientific history of Canada's nuclear program and invited them to join him at the conference reception which was sponsored by AECL.

The book is a collection of 21 chapters written by 16 authors, all of whom were intimately involved in the areas of research they record. (See the descriptive flier mailed with this issue of the CNS Bulletin) The authors present were: Don Hurst, Bernie Ullyett, Doug Milton, Geof Hanna, Howard Rae, Maurice Duret, Chuck Ells, Alastair Bain, Ralph Green, Archie Robertson, Fred Boyd. Unable to attend were: Gene Critoph, Art Marko, David Myers, Alex Eastwood, Bob Hart.

Following are excerpts from the remarks by Dr. Donald.G. Hurst at the book launch, on behalf of all of the authors. Dr. Hurst joined the Montreal Laboratory in 1944, subsequently became one of the senior directors of AECL at Chalk River and from 1972 to 1976 was president of the Atomic Energy Control Board. He was the primary initiator of the project which resulted in the book.

Dr. Donald Hurst speaks to those attending the "book launch" ceremony for the new technical history of AECL, "Canada Enters the Nuclear Age", in Toronto, June 8, 1997

Excerpts from remarks by Don Hurst

As you know, we are here to celebrate the publication of a book on the technical and scientific research that has been done at Chalk River and Whiteshell. I call the book the second component of an unplanned trilogy. The first component, published in 1988, is the book "Nucleus", which is a professional study of the political and corporate history of the Canadian nuclear project. Professor Robert Bothwell is the author. In Nucleus, research is outlined but not treated in detail. The third component of the trilogy will result from a series of monographs about the engineering of the CANDU nuclear power system. The monographs are being written by retirees from AECL's CANDU operations.

In 1989, as a result of a suggestion to AECL, Gene Critoph, and AECL vice-president, was asked to coordi-

nate the preparation of a technical history of AECL. Critoph assembled a small group of former AECL employees for what became the first meeting of "The Technical History of AECL Committee".

The outline of a book gradually took shape, mainly as a list of chapters and authors. A few of the authors began to prepare drafts, although there was still the possibility that a professional writer might be chosen; there was also the thought that such a writer might be provided with draft chapters written by the retirees. The focus of the book was to be research and development done in AECL laboratories; activities elsewhere would be considered only if they had relevance to research and development in AECL. 1985 was chosen as the cutoff date; this was later modified to permit up-dating by epilogues.

In all, 24 meetings were held; the last was in April 1994, by that time a draft had been submitted to AECL. The draft consisted of 21 chapters written by 16 authors, all of whom were retirees and members of THAC. Throughout the program Critoph supervised the effort, maintained contact with AECL, chaired, minuted and arranged the work of the Committee. He also wrote a major chapter, and coordinated the preparation, distribution and indexing of manuscripts. His retirement during the process in no way lessened his contribution. At present he is recovering from surgery, otherwise he would be at this podium now.

A controversial decision was made to allow only a very few names in the text. The result may be impersonal, cut the document is not cluttered with names and many real or imagined grievances are avoided.

During the early planning it was assumed that details of the CANDU nuclear power system would be included. By August 1990 AECL CANDU had decided not to participate fully. This was a very practical decision for several reasons. A better approach is underway as what I have called the third component of the trilogy.

Until final drafts of several chapters were received by AECL, no decision was made on the future of the work. During this time of uncertainty THAC considered fall-back positions, for example, the possibility of the document being issued as an AECL document. As such, it would have world-wide distribution to many libraries and government repositories. The decision by AECL to have a book published was a pleasant relief to the authors.

Today, the finished product is available, a fine-looking volume from the publishes, McGill-Queen's University Press. We mush now wait to see how the book is received by the media and the public. With good fortune, the book could help to remove some of the widespread ignorance of nuclear matters.

In the Preface, the assistance of many people is acknowledged and I shall not repeat those acknowledgements here. I am sure, though, that my fellow authors will support me in expressing thanks to AECL for its decision to proceed with publication, even in times of lean budgets.

The 11 authors present for the ceremony to launch the new technical history of AECL, "Canada Enters the Nuclear Age" pose with AECL president Reid Morden, vice-president David Torgerson, and chairman Robert Nixon offer the ceremony in Toronto, June 8, 1997.
Front row (left to right): Donald Hurst, Howard Rae, Bernie Ullyett, Maurice Duret, Ralph Green, Alistair Bain, Charles Ells.
Back row (left to right): Reid Morden, Fred Boyd, Geof Hanna, Doug Milton, Archie Robertson, David Torgerson, Robert Nixon.
Authors missing: Gene Critoph, Bob Hart, Alex Eastwood, Art Marko, David Myers.

Wolsong 2 Enters Commercial Operation

Wolsong 2, the second CANDU nuclear power plant in Korea, began commercial operation on July 1, 1997. It joins the first CANDU unit in Korea, Wolsong 1, which went into commercial service in 1983 and is one of Korea's top performing reactors. Wolsong 3 and 4 are scheduled to go into service in 1998 and 1999.

Construction of Wolsong 2 commenced in 1991 and the unit went critical in January 1997. Full power was achieved on April 28, 1997

Atomic Energy of Canada Limited did the plant design and engineering and coordinated the Canadian input. NPM Canada Inc. (a consortium of AECL, Agra Monenco, SNC-Lavalin and BFC Nuclear Managers oversaw the Canadian content of the nuclear steam supply system. Korea Electric Power Corporation (KEPCO) is the owner and was responsible for overall project management, construction and operation.

Books Available

Canada Enters the Nuclear Age:
A Technical History of Atomic Energy of Canada Limited as Seen From its Research Laboratories

by D. G. Hurst et al ISBN 0-7735-1601-8
McGill-Queen's lUniversity Press $52.00

This 430 page volume contains accounts of the research and development that led to the CANDU nuclear power reactor and other applications of nuclear science and technology conducted at the laboratories of Atomic Energy of Canada Limited by 16 authors who were involved.
(See article on "Book Launch" and flier mailed with this issue of the CNS Bulletin.)

Radiation in Perspective:
Application, Risks and Protection

94 pp ISBN 92-64-15483-3
OECD $27 (US)
Available in Canada from: Renouf Publishing Co,
5369 Canotek Road
Ottawa, Ontario K1J 9J3

Intended for non-specialists, this book reviews the development of radiation protection and internationally agree principles and addresses social and economic issues such as ethical questions, risk perception and cost of protection.

Consultation On Proposed Regulations

The Atomic Energy Control Board is inviting comments on proposed regulations to be issued when the recently passed Nuclear Safety and Control Act is put into effect early next year.

A set of 12 regulations can be obtained in hard copy or on a diskette in Wordperfect 6.1 format from:

Canada Communications Group
Distribution Logistics Services
Ottawa, Ontario K1A 0S7 FAX 819-994-1498

The regulations and the new Act can also be downloaded from the AECB Website: http://www.gc.ca/aecb

Comments must be submitted by August 31, 1997.

Ontario Hydro Nuclear Appointments

In May, Carl Andognini, executive vice-president and chief nuclear officer, Of Ontario Hydro announced a number of appointments.

Three "Site Vice-Presidents" were named:

- Jim Burpee — Bruce
- Ken Talbot — Pickering
- Bob Stickert — Darlington

Other vice-Presidents appointed were:

- Ken Nash — Nuclear Waste
- Pierre Tremblay — Nuclear Training
- Walter Lee — Regulatory Affair and Nuclear Assurance

The six advisers from the USA (in addition to Andognini) were formally assigned "wedge" (temporary) positions as follows:

- Warren Peabody — VP, Station Engineering Support and Chief Nuclear Engineer
- Richard Machon — VP, Managed Systems and Operational Performance Assessment
- Robert Ferguson — VP, Quality
- Brian Debs — VP, Regulatory Affairs
- Eugene Preston — VP, Operations and Maintenance
- Carolyn Stock — Executive Advisor for Nuclear Executive Systems and Staff Ombudsman

CNS news

CNS Annual General Meeting

The 1997 Annual General Meeting of the Canadian Nuclear society was held late Monday afternoon, 9 June 1997 at the close of the first day of the CNA/CNS Annual Conference at the Inn-on-the-Park Hotel in Toronto with over 40 members present.

The meeting followed the usual format with acceptance of the minutes of last year's AGM, held in Fredericton, N.B., followed by reports on different aspects of the Society's activities.

Outgoing president Hong Huynh noted the strong financial position of the Society, the increased membership, the launching of a new education program and the revised agreement with the American Nuclear Society that had been signed just the previous week. He thanked his fellow Council members, Branch executives, conference organizers and all members of the Society for the very successful year.

The Treasurer's report and the audited Financial Statement are printed elsewhere in this issue.

The various Committee and Division chairpersons had each prepared succinct reports of the activities of their groups.

One new piece of business was the proposal, presented orally by Fred Boyd, that the CNS examine in detail incorporation as a separate, non-profit, organization. Although no vote was taken a show of hands indicated total support for this initiative by those present (See a separate article.)

As chairman of the Nominating Committee, Jerry Cuttler presented a proposed slate of officers and Council members. David Freeman, who had been nominated as a "member-at-large" was nominated as secretary. With that change the slate was declared elected.

Following a brief address by incoming president Ben Rouben (reprinted in this issue) the meeting was adjourned about 7 p.m.

CNS Executive for 1997-98: (Left to right): Jerry Cuttler, 2nd vice-president; Ken Smith, treasurer; Ben Rouben, president; Jim Platten, outgoing secretary; Paul Thompson, 1st vice-president; Hong Huynh, past-president; David Freeman, incoming secretary.

Ben Rouben – CNS President

Ben Rouben

The newly elected president of the Canadian Nuclear Society for 1997-98, Dr. Benjamin (Ben) Rouben, says that he knew he wanted to be a physicist when he was in high school in Outrement, Quebec. He followed that dream and received a B.Sc. (Hon.) In mathematical physics from McGill University in 1965 and then went on to obtain a Ph.D. in theoretical physics from the Massachusetts Institute of Technology in 1969. Returning to Canada he pursued research in nuclear structure at the Universite de Montreal from 1969 to 1975. That year he joined Atomic Energy of Canada Limited at Sheridan Park to work on reactor physics. He was appointed to his present position of Manager of the Reactor Core Physics Branch in 1993.

Ben has been active in the CNS since the early 1980s, first on the executive of the Toronto Branch and then on the national CNS Council. Over the years he has served in a number of capacities, such as: Division Chair, Treasurer, Secretary and technical Program Chair for CNS Conferences. In 1995 he was elected 2nd vice-president, progressing to 1st vice-president last year and named president at the Annual General Meeting on June 9, 1997.

He is also a member of the American Nuclear Society.

Ben lives in Toronto with his wife Denise, daughter Caroline and son Steve (who will probably see less of him over the coming year as he fulfils the demanding role of CNS president).

Ben says that he hope to be able to emulate his predecessors and contribute to the continued growth of the Canadian Nuclear Society.

CNS Incoming President's Message

Ed. Note: *Following is the message presented by Dr. Ben Rouben on taking over as President of the Canadian Nuclear Society at the Annual General Meeting held June 9, 1997 at the Inn-on-the-Park Hotel in Toronto, during the CNA/CNS Annual Conference*

My message will be short.

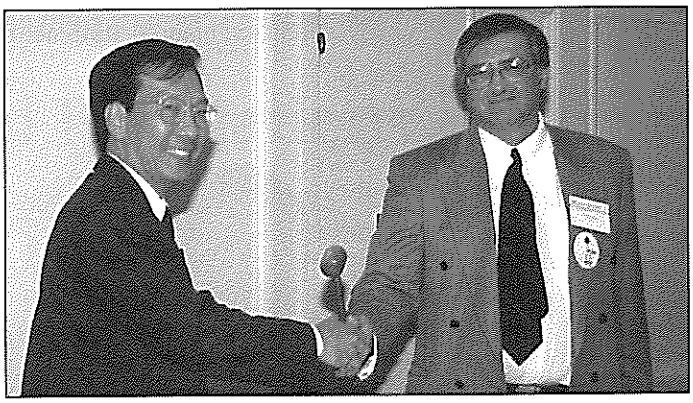
Under Hong Huynh's most able leadership, the CNS has had another very successful year. You have heard about the great variety of activities which the Divisions, Branches, and Committees of the CNS have organized in the past twelve months. This will be a benchmark difficult to match. I will be looking to each member of the incoming Council for assistance in facing the challenges of the coming year.

Included in these challenges are once again a number of conferences, which I hope will win favour with a lot of registrants.

In the rest of 1997 we will have:

- the 20th Nuclear Simulation Symposium in Niagara-on-the-Lake Sept. 7-9,
- the 5th CANDU Fuel Conference in Mississauga Sept. 21-24, and
- the 4th CANDU Maintenance Conference in Toronto Nov. 16-18.

Then in 1998 May the CNA and CNS are co-sponsoring PBNC 98, the 11th Pacific Basin Nuclear Conference, in beautiful Banff. This will be a major international conference, and it should attract a large number of our colleagues from abroad. I hope many of you will be there. The CNA is holding its next annual conference at the same time as PBNC 98, so we in the CNS will face another first-time challenge: organize our annual CNS Conference on our own. This will be held 1998 October 18-21, in Toronto. Please mark your calendars!



Outgoing CNS president, Hong Cuynh (L) hands over the presidential gavel to Ben Rouben, CNS president for 1997-98, at the Annual General Meeting, June 9.

There will also be many other challenges. Not least of which will be the polling of members on the question of CNS incorporation, and, if given the green light, the planning and execution of this big step! Another exciting challenge, which will require much effort and preparation, will be the bringing to life of our new Education Program (proposed by Jerry Cuttler).

I humbly hope that I and the incoming Council can be equal to the task ahead of us, and that we can contribute to the further growth and maturity of the CNS. On a final note, I would like to hope that I can count on your help. Please continue to support the CNS as you have in the past, and encourage all your colleagues who are not yet members to make this their Society too!

Ben Rouben

Incorporation

Ed. Note: *Those attending the Anual General Meeting of the Canadian Nuclear Society endorsed an action by the CNS Council to examine in detail the incorporation of the CNS as a separate, non-profit, organization. Following are some of the points presnted at the meeting to support that action.*

1. The CNS was formally created in 1979 as a "technical society" of the CNA. In fact the original name was "The Canadian Nuclear Society - The Technical Society of the Canadian Nuclear Association". Legally, the Society is part of the CNA.

   For background see Phil Ross-Ross' article, "The Formative Years of the CNS, 1976- 1984" in the spring 1992 issue, Vol. 13, No. 1, of the CNS Bulletin.
2. For many years the CNA subsidized the CNS, providing services of far greater value than the CNS payment or contribution. That has changed and the Society is now paying close to the value of the services provided through the CNA office.
3. The CNS is now 19 years old, has a significant membership, is financially very sound, and has established a reputation nationally and internationally as a major technical and scientific organization within the nuclear community.
4. Although the CNS has, in recent years, acted as a separate society it remains legally a subsidiary of the CNA. This is the basis for the refusal of the Atomic Energy Control Board to allow its staff to become members. This legal dependancy could undermine the credibility of the Society when making submissions to hearings, panels, etc.
5. Legal separation does not, and would not, imply that the working relationship of the Society with the CNA need change, but it would permit change if desired.

Treasurer's Report

Ed. Note: *The CNS fiscal year is the calender year, even though the term of the Executive and Council is from AGM to AGM, typically June. The following report was presented at the Annual General Meeting, June 9, 1997.*

The Auditor's Report for 1996 (see elsewhere in this issue) shows that the CNS continues to maintain a strong financial position. For 1996, total revenue was $211,846, well above the 1995 level. Total expenditures were $129,429, which is lower than in 1995. The end result was a very good year, with an excess of revenue over expenditures of $82,417. As of the end of 1995, the CNS accumulated surplus was about $320,000.

The favourable net income for 1995 can be largely attributed to two very successful conferences, the Geological Disposal Conference and the Simulation Conference, which contributed a combined net revenue of about $96,500. The Reactor Safety Course provided a surprising $24,500, mainly due to the large attendance. The Fuel Handling Conference and the Radiation Impact Seminar provided lesser but nevertheless important contributions. In all cases, the conference organizing committees deserve our considerable appreciation.

We also have to acknowledge each member's contribution through annual fees. In 1996, membership fees accounted for about 1/5 of total revenue (about $39,000).

This year we do not expect to see a repeat of the 1996 level of conference income, and we expect expenditures to be higher. Therefore, we will be quite happy if we can just break even on the year.

At last year's AGM I rpoposed that membership fees should be increased by $5.00 for 1997. However, given the better than anticipated conference revenue in 1996, that proposal was not pursued.

The 1996 Auditor for both the CNS and the CNA was the firm of Doanne Raymond. We are satisfied with the work of this firm, and I recommend that Doanne Raymond be contracted to handle the audit duties for 1997.

K.L. Smith, CNS Treasurer – 1996/97

Auditor's Report

To the Members of the Canadian Nuclear Society

We have audited the balance sheet of the Canadian Nuclear Society as at December 31, 1996 and the statements of operations and members' equity for the year then ended. These financial statements are the responsibility of the Society's Council. Our responsibility is to express an opinion on these financial statements based on our audit.

We conducted our audit in accordance with generally accepted auditing standards. Those standards require that we plan and perform an audit to obtain reasonable assurance whether the financial statements are free of material misstatement. An audit includes examining, on a test basis, evidence supporting the amounts and disclosures in the financial statements. An audit also includes assessing the accounting principles used and significant estimates made by management, as well as evaluating the overall financial statement presentation.

In our opinion, these financial statements present fairly, in all material respects, the financial position of the Society as at December 31, 1996 and the results of its operation and changes in its financial position for the year then ended in accordance with generally accepted accounting principles.

Doane Raymond
Chartered Accountants
Toronto, Canada
February 24, 1997

Canadian Nuclear Society
Statement of Operations

Year Ended December 31	1996	1995
Income		
Membership fees	$ 38,916	$ 38,017
Publications	6,107	4,503
Interest	10,243	10,233
	55,176	52,753
Society projects – excess of income over expenditures		
Annual conference	15,918	14,522
Adjustments from 1994 Conferences/Courses	–	(2,485)
1995 Simulation Symposium	–	7,973
1995 CANDU Maintenance Conference	487	71,161
1995 CANDU Fuel Conference	–	8,551
1995 Reactor Physics Course	490	7,670
Environmental Assessment – Fuel Disposal Concept	(597)	597
1996 CANDU Fuel Handling Conference	10,536	–
1996 International Conference on Simulation Methods	40,807	–
1996 Geological Disposal Conference	56,743	–
1996 Reactor Safety Course	24,477	–
1996 Symposium on Radiation Impacts	7,809	–
	156,670	107,989
Total income	211,846	160,742
Expenses		
Net expenditures by branches	6,138	15,832
Committees		
Membership	2,486	8,468
Program	1,806	1,044
Fusion	–	29
Awards	956	2,256
Education and public affairs	7,028	1,219
Women in Nuclear	1,500	95
Inter-society relations	1,672	993
	15,448	14,104
Office support	50,000	48,000
Office services		
Audit fees	3,700	2,500
Casual Labour	186	–
CNS Council expenses	1,652	2,182
Stationery and office supplies	3,642	4,856
Bank charges	407	291
Credit card charges	222	162
Computer programming	–	1,152
Telephone	1,368	1,367
Insurance	1,242	1,188
Postage	9,752	12,883
Printing and copying	1,105	5,697
Courier charges	69	280
	23,345	32,548
Canadian Nuclear Society Bulletin	30,852	22,737
Special Projects		
Student conference	987	1,365
Proceedings and promotional supplies	680	3,717
Officer's seminar	1,571	3,514
Miscellaneous / Other	408	–
ZEEP - 50th anniversary	–	1,515
	3,646	10,111
Total Expenses	129,429	145,332
Excess of income over expenses	82,417	15,410
Members Equity, beginning of period	221,178	205,768
Excess of income over expenses	82,417	15,410
Members Equity, end of period	303,595	221,178

Canadian Nuclear Society
Balance Sheet

Year Ended December 31	1996	1995
Assets		
Current		
Cash		
Bank accounts	$ 204,046	$ 173,874
Nuclear Operations Division	1,793	1,823
Branch bank balances	18,314	16,812
Receivables	36,878	25,015
Accrued interest	749	500
Prepaids	260	–
Marketable securities (market value - $49,919; 1994 - $85,347)	53,108	52,188
Conference advances	23,000	8,000
Due from Canadian Nuclear Association	–	8,737
	338,148	286,949
CNS share of Education Fund assets (Note 2)	17,000	17,000
	$ 355,148	$ 303,949
Liabilities		
Current		
Payables and accruals	$ 29,643	$ 54,543
GST payable	65	2,046
Subsequent year's membership fees received in advance	528	9,182
Due to Canadian Nuclear Association	4,317	–
	34,553	65,771
Surplus		
Accumulated members/ equity	303,595	221,178
Education Fund (Note 2)	17,000	17,000
	320,595	238,178
	$ 355,148	$ 303,949

On behalf of the Canadian Nuclear Society Council

Canadian Nuclear Society
Notes to the Financial Statements
December 31, 1996

1. **Summary of Significant accounting policies**
   (a) **Revenue recognition**
   Membership fees are included in income in the fiscal year to which they relate.
   Interest and other income is recorded on the accrual basis.
   (b) **Marketable securities**
   Marketable securities are carried at cost adjusted for amortization of premiums or discounts.

2. **Education Fund**
   From 1988 to 1991, annual contributions amounting to $3,000 from the Society and $7,000 from the Canadian Nuclear Association (CNA) were allocated from the income from the annual conference. In 1995, the Society made an additional contribution of $5,000. The principal remains the property of the CNA and the Society. The interest on these funds is available for education purposes to local branches of the society.

	1996	1995
The total fund is composed as follows:		
Principal contributions		
Canadian Nuclear Association	$ 28,000	$ 28,000
Canadian Nuclear Society	17,000	17,000
	45,000	45,000
Accumulated interest available for education activities, beginning of year	7,500	9,387
Fund assets as of beginning of year	52,500	54,387
Interest earned during the year	3,090	3,113
Allocations during the year	(3,050)	(5,000)
Fund assets as of end of year	$ 52,540	$ 52,500

NEWS OF MEMBERS

Retirements: Bob Morrison, Ted Thexton

Two events were held June 24, 1997 to mark the retirement of **Dr. Robert W. (Bob) Morrison** from the post of director General, Uranium and Nuclear Energy at Natural Resources Canada, which he has held since 1980. Bob officially stepped down at the end of March but stayed on as a special adviser for a few months.

One event was an official party held at NR Canada, complete with talks, presentations and even a video in which Bob was interviewed. The other was a more informal dinner gathering where his friends and associates made a number of generally friendly remarks about working with him.

Bob earned a B.Sc. In engineering physics from McGill University and a doctorate in particle physics from the University of Paris. After two years in California and a further two years in Peru he joined the physics department of Carleton University in Ottawa in 1968 where he stayed until he joined the then Department of Energy, Mines and Resources. From 1974 to 1990 he taught a graduate seminar on Science and Technology at Carleton University where he remains an adjunct professor.

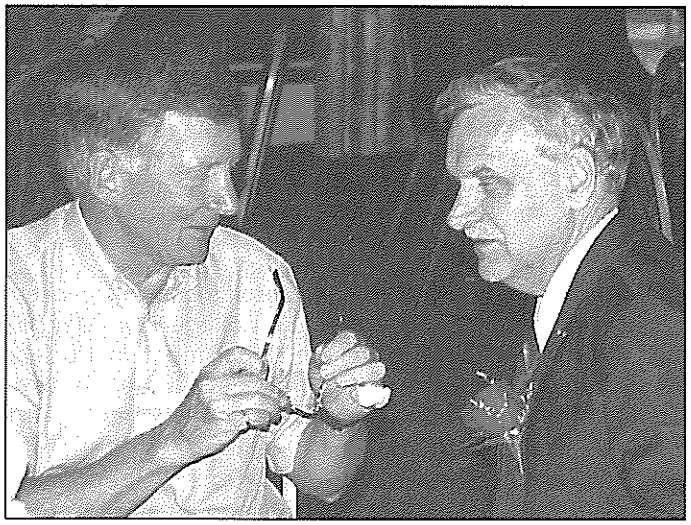
Over the years Bob played a key role in the development of national policies related to uranium and nuclear energy. His office was often the focal point of interdepartment consultations. In 1995 he chaired the federal government's working group which conducted a program review of Atomic Energy of Canada Limited

Among his many international roles he served as chairman of the Steering Committee of the Nuclear Energy Agency of the Organization for Economic Cooperation and Development from 1991 to 1994. In 1996 he accompanied then Natural Resources Minister Anne McLellan on visits to Korea and China.

Bob was presented with the Ian McRae Award by the Canadian Nuclear Association in 1995 for his many contributions to the Canadian nuclear program.

Ed. Note: *Carmel Letourneau, Lindsay Patrick and Bob Whillam of Morrison's former staff extend their thanks to all who contributed to the tribute to Bob on his retirement.*

H. E. (Ted) Thexton retired from Natural Resources Canada at the end of February 1997. Ted had been Director, Nuclear Energy (a position which had several variations of title over the years) since 1981, with a two-year leave to serve as Director of Nuclear Development at the Nuclear Energy Agency of the OECD in Paris.



At his retirement party, June 24, 1997, Bob Morrison (R), formerly Director General, Uranium and Nuclear Energy at Natural Resources Canada chats with Ted Thexton who retired from the same department in February.

After graduating from the University of Manitoba, Ted joined the Civilian Atomic Power Department of Canadian General Electric Company. Then he moved to the Whiteshell Laboratories of Atomic energy of Canada Limited where he worked on CANDU fuel development. In 1979 he moved to AECL's Corporate office in Ottawa where he was primarily involved in CANDU marketing.

At NRCan, Ted has played a key role in many nuclear policy issues including the financing of the China CANDU sale and the bid to Turkey, program reviews of AECL and, more recently, of Whiteshell. He is given much credit for maintaining funding for the Condensed Matter Science Program and for keeping the MOX program alive.

Ted was an early member of the Canadian Nuclear society. With the high regard and respect he has gained in the nuclear industry he will undoubtedly be kept active.

Ed. Note: *With the retirements of Bob Morrison and Ted Thexton along with that of Dick Williams, Director, Uranium in the same department, last year, NRCan has lost its three most experienced and knowledgeable advisers. Further, the Branch which Morrison headed has now been re-structured as two divisions within a new Energy Resources Branch.*

BRANCH NEWS

Ed. Note: The following is drawn largely from the last report by Ben Rouben, now president of the CNS, in one of his roles, as Branch Chairman.

Bruce Branch

The Branch held a seminar on June 3. The guest speaker was Mr. Peter Stevens-Guille, Manager Used Fuel Disposition, Ontario Hydro. The title of the talk was "What Hydro Plans To Do With Its Used Nuclear Fuel".

Chalk River Branch

The Branch continues to co-sponsor technical speakers for the local campus of Algonquin College. On May 15, Ms. Beth MacGillivray, from the Department of Nuclear Medicine, Ottawa General Hospital, gave a talk entitled, "Connections: A Connect-the-Nuclear-Dots Game". Part of the abstract for the talk read:

> "Nuclear Medicine has evolved from a promising medical specialty about 40 years ago when radioactive compounds were first used to treat cancer, elicit biochemical information from patients, and provide images of internal organs. Today, Nuclear Medicine is at the frontier of discovering and understanding complex physiological processes of the brain, heart, and other organ systems. Essential to many of these applications are isotopes created here at CRL."

Ms. MacGillivray explained how nuclear medicine is connected to seemingly unrelated things such as the O.J. Simpson trial, the Pittsburgh Penguins, and Band-Aids. She also described the enormous impact of radioactive isotopes on various fields of science, industrial uses of nuclear technology, and valuable medical applications developed by Canadians.

On May 22, the Branch presented a seminar by Prof. Murat Saatcioglu, Dept. of Civil Engineering, University of Ottawa. The talk was entitled "Lessons Learned from Previous Earthquakes". The Abstract for the talk read:

> "The performance of structures during previous earthquakes will be discussed. The emphasis will be placed on shortcomings of previous design practice in seismically active regions. Design flaws in building and bridge structures and their effects on structural response will be highlighted. Examples of structural response, including those of the recent Northridge Earthquake, will be presented. Improved seismic design and detailing requirements will be discussed with relevant references made to the current NBCC code and CSA Standards. A brief review of seismological aspects of earthquake engineering will also be presented, with a discussion of plate tectonics and seismicity of the world."

The presentation provided an overall perspective of earthquake hazard mitigation through sound engineering practice, and a feel for the significance of earthquake-resistant design on performance of structures.

Manitoba Branch

Branch Chair Morgan Brown continues to be very active in presentations to schools on nuclear issues. On May 15 Morgan gave a talk at Pierre Radisson Collegiate in Winnipeg on nuclear energy and waste management. Morgan's report on this outing follows:

> " My talk to the Grades 10 and 11 science students at the Pierre Radisson Collegiate (Winnipeg) went well. I was quite surprised by the very pro-nuclear stance of one of the teachers - he had seen the destruction caused by power dams, and the lack of strict emission standards in fossil-fired plants (Flin Flon's smelter in particular).
>
> This morning I had an interview/chat with a Grade-11 student from Kenora, who is interested in becoming a nuclear physicist. I talked with him about my own work in engineering, as well as what I knew of physics and the work in Canada."

Ottawa Branch

On June 20, a field trip was held for 24 High School Students (and two teachers) to the nuclear medicine department of the Ottawa General Hospital. The trip was organized by Sadok Guellouz and hosted by Beth MacGillivary. The students gave positive feedback and the teachers suggested a similar trip just for science teachers. This is being considered for the fall.

A proposed end of season dinner with Brian Debs, one of the "group of seven" team at Ontario Hydro had to be deferred until the fall.

Pickering Branch

The Pickering Branch (with the approval of the CNS Council) has made a grant of $1,000 to Christie Low, an OAC student at Exeter High School in Ajax, to assist her in attending the Deep River Science Academy this summer. Christie was chosen as one of only 80 students from across Canada . The total cost for the 6-week program is $3700. (See photograph).

Marc Paiment (L), chairman of the CNS Pickering Branch, presents a cheque for $1,000 to Christie Low, a student at Exeter High School in Ajax, to assist her attendance at the Deep River Science Academy.

Sheridan Park Branch

This spring the CNS Sheridan Park Branch supported and participated in two regional Science Fairs, in Hamilton-Wentworth and in Peel Region, by donating a total of $1150 for prizes and providing judges.. The judges viewed 130 projects at the Peel Fair and 160 at Hamilton. Two prizes were given at the junior level and one each at the intermediate and senior levels at both fairs.

On May 24 the Branch organized a tour of Pickering NGS for about 10 high-school students and 10 teachers. The tour was organized by Ted Wessman, of the Branch Executive, who also organized the participation in the science fairs. Jerry Cuttler helped facilitate the tour which included visits to the control room, turbine building, spent-fuel bay, grounds and nature preserve.

On June 4, the Branch presented a seminar by Mr. Ken Talbot, Site Vice-President, Pickering Nuclear Generating Station, Ontario Hydro. The title of the talk was "Turnaround of the Pickering Nuclear Generating Station". Mr. Talbot discussed the recent difficulties encountered at Pickering and the solutions proposed to address these problems. Some biographical notes on Mr. Talbot follow:

On the occasion of the tour, Jerry Cuttler CNS Education) and Ted Wessman (CNS-SP Education) discussed briefly:

- Objectives of CNS Education Initiatives: Establish rapport with students and teachers to see what they are interested in to get more students involved in science and nuclear engineering.
- Resources/roles of CNS members to assist teachers/students interested in doing projects on Nuclear Engineering
- Liaison Mechanisms - Web Page and E-Mail/phone contacts highlighted
- Award Paper Initiative (Kwok Tsang, Branch Vice-Chair)

In addition, the following handouts were distributed:

- CNS Education Objectives, list of project areas and resource support
- Copies of SP Branch Homepage (colour version)
- Copies of Prof. A. Reynolds' book "Blue Bells and Nuclear Energy"
- Seminar announcements

On June 11 Dr. Nguyen Tien Nguyen, Director General, Vietnamese Atomic Energy Commission presented a seminar on "Vietnam's Nuclear Power Plans". The Branch took advantage of Dr. Nguyen's visit to Canada, as heading of a delegation of senior officials from the Vietnamese government to the annual CNA/CNS Annual Conference.

New Members

We welcome the following new members of the Canadian Nuclear Society who joined between February 6 and July 3 (the cut-off date for this issue).

Kam Aydogdu
Theodore S. Brus
Charles Renaud Doucet
Jennifer Hartman
Petre I.G. Iliescu
Janusz Jung
Gary Leitch
Binh-Le Ly
Kris K. Mohan
Nguyen Tien Nguyen
Antonino F. Oliva
Laurence Andrew Robitaille
Uditha P.M. Senaratne
John Walter Thompson
Jacek Urbanowica
John Brewer
Robert S. Dixon
Abdul Hameed
Len J. Hiebert
Sergej Jacenko
Peter J. Laughton
Marilyn F. Lightstone
Mark Lunney McIntyre
Mohammad Reza Nejat
David R. Novog
Steven Patrick Portelli
David Mathiew Schreiter
Evgueni N. Sokolov
Robert T. Thurier
Raymond Yu

Obituary

Another early member of the Canadian nuclear program, **Dr. Angus Charles (Chic) Whittier**, died suddenly on May 27, 1997 in Mississauga, Ontario.

Chic was one of the original members of the small team that designed NPD, Canada's first nuclear power plant, in the late 1950s. After obtaining a Ph.D. from McGill University in Montreal, Chic joined the nuclear project at Chalk River before going to Peterborough in 1955 to join Canadian General Electric Company on the NPD project were he was in charge of all physics aspects. In the 1970s Chic joined the Power Projects group of Atomic Energy of Canada Limited at Mississauga where he became branch head of physics. He was an early member of the Canadian Nuclear Society and a constant supporter.

(The editor particularly remembers Chic as a wise and friendly mentor in reactor physics and shielding during the NPD project.)

CALENDAR

1997

August 17 - 21

International Conference on Neutron Scattering
Toronto, ON
contact: Dr. W.B.L. Buyers
AECL Chalk River Lab.
Chalk River, ON
Tel: 613-584-3311
Fax 613-584-1849

Sept. 7 - 9

Nuclear Simulation Symposium
Niagara-on-the-Lake, ON
contact: V.S. Kirshnan
AECL
Mississauga, Ontario
Tel: 905-823-9060 ext. 4555
Fax: 905-823-2584
e-mail: krishnanv@aecl.ca

September 22 - 24

5th International CANDU Fuel Conference
Toronto, ON
contact: Dr. J. Lau
AECL - SP
Mississauga, ON
Tel: 905-823-9060 ext. 4531

September 30 - October 4

NURETH-8, 8th International Topical meeting on Nuclear Reactor Thermal Hydraulics
Kyoto, Japan
contact: Dr. Jerry Cuttler
AECL - Sh. Pk.
Mississauga, ON
Tel: 905-823-9060 ext. 2556
Fax: 905-855-0945
e-mail: cuttlerj@spkb.candu.aecl.ca

October 5 - 10

Global '97 International Conference on Future Nuclear Systems
Yokohama, Japan
contact: Dr. Jerry Cuttler
AECL - Sh. Pk.
Mississauga, ON
Tel: 905-823-9060 ext. 2556
Fax: 905-855-0945
e-mail: cuttlerj@spkb.candu.aecl.ca

October 6 - 10

International Conference on Mathematical Methods and Supercomputing for Nuclear Applications
Saratoga Springs, NY
contact: Dr. M.R. Mendelson
Knolls Atomic Power Lab
Schenectady, N.Y.
Tel: 518-395-7046
Fax: 518-395-4422

October 14 - 18

2nd International Conference on Isotopes
Sydney, Australia
contact: Dr. Clarence Hardy
Australian Nuclear Assoc.
Peakhurst, NSW, Australia
Tel: 61-2-9579-6193
Fax: 61-2-9570-6473
e-mail:
cjhardy@ozemail.com.au

November 16 - 20

ANS Fall Meeting
Albuquerque, New Mexico
contact: American Nuclear Society
La Grange Park, Illinois
Tel: 708-352-6611
Fax: 708-352-6464

November 16 - 18

4th CANDU Maintenance Conference
Toronto, ON
contact: D. Iafrate
Ontario Hydro
Darlington, ON
Tel: 905-697-7496

Dec. 8 - 10

International Conference on Plant Life Management
Prague, Czech Republic
contact: Alan Wagstaff
c/o Nuclear Engineering International
Dartford, Kent, England
Fax: 44-1322-273748

1998

March ?

CNA/CNS Winter Seminar
Ottawa, ON
contact: Sylvie Caron
CNA/CNS Office
Tel: 416-977-7620
Fax: 416-979-8356
e-mail: carons@cna.ca

March 27, 28

CNS/CNA Student Conference
Kingston, ON
contact: Dr. H. Bonin
Royal Military College
Tel: 613-541-6000 ext. 6613
Fax: 613-545-0783

May 3 - 7

11th Pacific Basin Nuclear Conference
Banff, Alberta
contact: Ed Price
AECL Sheridan
Tel: 905-823-9060 ext. 3066
Tel: 613-584-3311
Fax: 613-584-1849
e-mail: pricee@candu.aecl.ca

May 24 -28

CRPA Annual Conference
Ottawa, Ontario
Contact: Ms. Cait Maloney
c/o Atomic Energy
Control Board
Ottawa, Ontario
Tel: 613-943-8948
Fax: 613-996-2049
e-mail:
maloney.c@atomcon.gc.ca

June 7 - 11

ANS Annual Meeting
Nashville, Tennessee
contact: American Nuclear Society
La Grange Park, Illinois
Tel: 708-352-6611
Fax: 708-352-6464

June 14 - 18

12th International Symposium Zirconium in the Nuclear Industry
Toronto, Ontario
contact: G.D. Moan
AECL
Mississauga, ON
Tel: 905-823-9060
Ext. 3232

June 21 - 24

3rd CNS International Steam Generator and Heat Exchanger Conference
Toronto, Ontario
contact: R. Tapping
AECL-CRL
Chalk River, ON
Tel: 613-584-8811
Ext. 3219

June 28 - July 2

ICENES '98 – 9th International Conference on Emerging Nuclear Energy Systems
Tel Aviv, Israel
contact: Dr. Dan Knassim
POB 1931 Ramat Gan 52118
Tel: 972-3-613-3340
Fax: 972-3-613-3341

October 18 - 20

CNS Annual Conference
TBD
contact: Sylvie Caron
CNS Office
Toronto, ON
Tel: 416-977-7620 ext. 18
Fax: 416-979-8356
e-mail: carons@cna.ca

October 25 - 28

ENC '98 International Nuclear Congress and World Exhibition
Nice, France
contact: ENC '98 Secretariat
European Nuclear Society
Berne, Switzerland
Tel: 41-31-320-6111
Fax: 41-31-382-4466
e-mail: carons@cna.ca

Nov. 30 - Dec. 4

Trends in Design and Development of Evolutionary Water-Cooled Reactors
Seoul, Korea
contact: J. Cleveland
IAEA
Vienna, Austria
Fax: 43-1-2060-20607
e-mail:
official.mail@iaea.org

1999

October 1999

3rd International Conference on Containment Design and Operation
Toronto, Ontario
contact: K. Weaver
Ontario Hydro
Toronto, ON
Tel: 416-592-4050

?? 1999

International Conference on Effects of Radiation on In-Reactor Corrosion
contact: V. Urbanice
AECL-CRL
Tel: 613-584-4676

DEADLINE:
The deadline for the next issue, which will be published about the end of September, will be September 19, 1997

ATOMIC ENERGY OF CANADA LIMITED - JOB OPPORTUNITIES
Safety Analysts; Control, Instrumentation, and Electrical Engineers; Process System, Equipment, and Mechanical Engineers; Robotics Engineers; Human Factors Engineers.

AECL has several junior and intermediate level vacancies for both term assignments and permanent positions in support of operating CANDU stations and developing designs. Work locations include Mississauga, Chalk River, and operating station sites.

Individuals with experience and qualifications in the following disciplines are required:

Safety Analysts

- Perform design basis accident analysis for CANDU reactors on heat transport, containment and moderator systems using state of the art computer codes
- Prepare computer models of reactor systems, run simulations, prepare analysis reports in support of new and existing licenses, prepare proposals and interact with client safety staff.

Control & Instrumentation, Electrical Engineers

- Review and specify C&I loop design, performance and operational requirements at the device and system level
- Good knowledge of nuclear or process control systems and instrumentation or electrical system fundamentals is essential
- Experience with some of the following is desirable: qualification of instruments for hostile environments, computer control systems, electrical power systems design, selection of electrical equipment, and real time computer systems control.

Process System, Equipment and Mechanical Design Engineers

- Perform process system design including system flowsheets, equipment sizing, design calculations, specification of system requirements, preparation of equipment specifications, environmental qualification and test requirements
- Design mechanical components and mechanisms for reactor and fuel handling equipment
- Experience with system design or equipment design and manufacturing is essential
- Good knowledge of process or mechanical equipment, valves, pumps, heat exchangers, pressure vessels, piping and fittings

Electrical Power Systems Engineer
[have new grad for C9, but company short of this skill]

- Carry out conceptual and detailed electrical power system design
- Prepare system design requirements documentation, and system design manuals
- Prepare single-line diagram designs, block diagrams, and electrical load lists
- Prepare technical specifications for electrical equipment
- Perform design calculations and analyses using state-of-the-art software
- Must have thorough understanding of: electrical engineering distribution theory and design principles; and load distribution and control application using modern PLC and digital-computer based control and monitoring systems

Robotics Engineers

- Carry out conceptual and detailed instrumentation, control and electrical design for a large, intricate, robotics system that performs the on-line refueling of a CANDU reactor
- Demonstrated theoretical and practical experience in the detailed design and documentation of precise, high accuracy, electrical and hydraulic drive systems for large, heavy mechanical equipment is essential

Human Factors Engineers

- Provide specialized human factors and cognitive science design and analysis input to projects involving new designs or enhancements to existing designs for CANDU and research reactor projects
- Provide support to plant system design engineers to integrate human factors into AECL products and services
- Develop computerized displays and control room panel layouts to meet facility requirements.

AECL leads Canada's nuclear export business. It develops, markets and manages the construction of CANDU power reactors and MAPLE research reactors. AECL provides support services to operating reactors in Ontario, Quebec, New Brunswick, Argentina, Korea and Romania. AECL is a Crown corporation of the Government of Canada.

To be eligible for employment with AECL, applicants must satisfy both immigration and enhanced security clearance requirements. All positions require a Bachelor or higher Degree in Engineering. For the junior positions a minimum of 2 years' related work experience preferably in the nuclear field is required. The ability to work effectively in a team environment is essential and candidates must have excellent oral and written communication skills.

We thank all applicants, however, only those candidates selected for an interview will be contacted.
For consideration, please send a covering letter and resume to Linda Slade, Human Resources Advisor, AECL - Sheridan Park, 2251 Speakman Drive, Mississauga, Ontario, Canada, L5K 1B2 or Email recruit@aecl.ca or by FAX (905) 823-9182.

For further information on AECL please visit our WEB site at www.aecl.ca.

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PBNC 98

How will nuclear power energize the Pacific Rim in the 21st century ?

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