CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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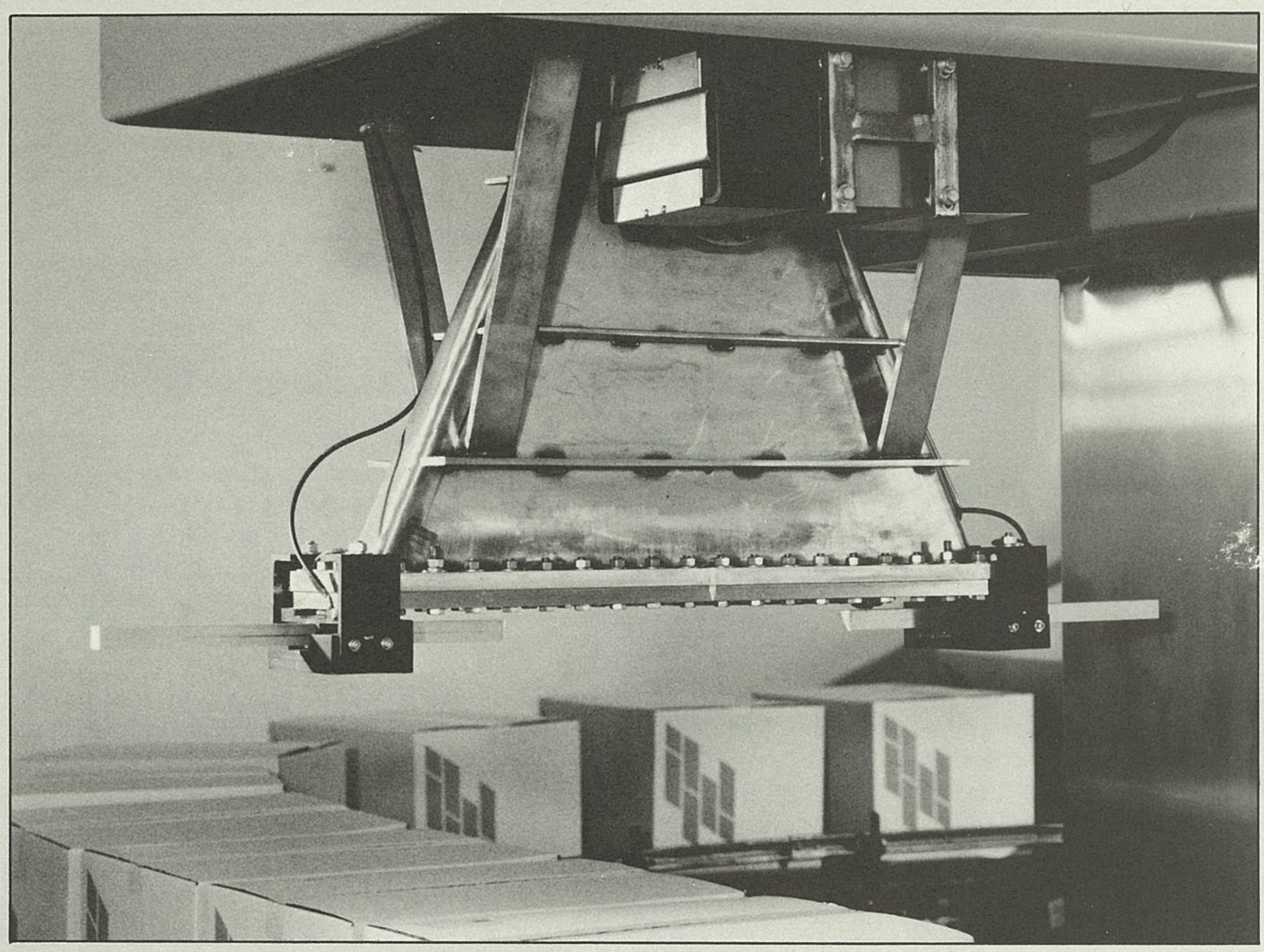

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COVER PHOTO:

The cover photograph is of the "business end" of the AECL IMPELA accelerator located at the Whiteshell Laboratory.

(Photo courtesy of AECL Accelerator Business Unit)

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

CNS provides Canadians interested in nuclear energy with a forum for technical discussion. For membership information, contact the CNS office, a member of the Council, or local branch executive. Membership fee is $55.00 annually, $25.00 to retirees, $15.00 to students.

La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ils peuvent participer à des discussions de nature technique. Pour tous renseignements concernant les inscriptions, veuillez bien entrer en contact avec le bureau de la SNC, les membres du Conseil ou les responsables locaux. La cotisation annuelle est de 55.00 $, 25.00 $ pour les retraités, et 15.00 $ pour les étudiants.

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AECL Sells New Accelerator

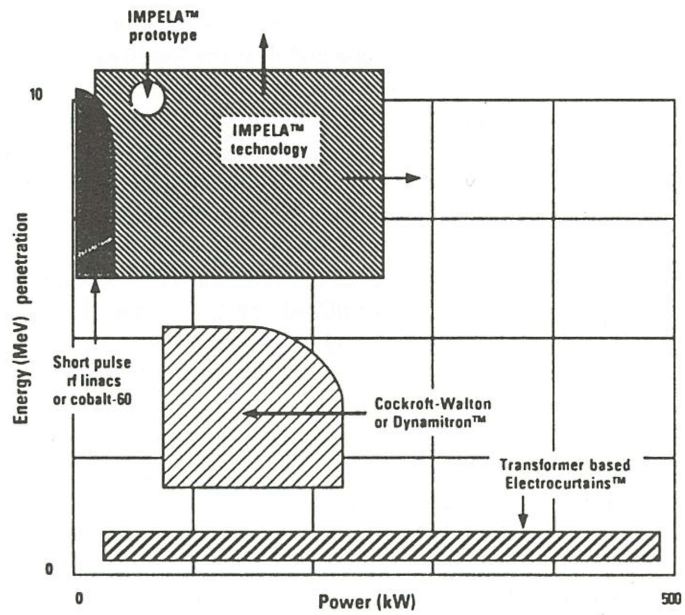
Andrew Stirling, General Manager of the AECL Accelerators, announced recently the first sale of the group's new IMPELA 10 MeV, 50 kW electron beam accelerator to E-Beam Services, Inc. of the USA. The unit will be installed in E-Beam's plant in Cranbury, New Jersey.

The 50 kW IMPELA is the most powerful 10 MeV industrial electron linear accelerator in operation in the world. The high penetration and accurate beam control makes it ideal for processes such as the sterilization of medical products, cross-linking of plastics and disinfestation of bulk products.

IMPELA (Industrial Material Processing Electron Linear Accelerator) is the trademark of a family of accelerators developed by AECL Research and now being engineered and marketed by the AECL Accelerator business unit located in Kanata near Ottawa.

IMPELA accelerators combine the best features of continuous wave machines (which have a number of problems and are large) and conventional pulse units by producing long pulses. This allows the accelerating gradient to be controlled during each pulse, providing constant beam quality. The result is a single structure accelerator which can deliver high energies and powers. The 10 MeV assembly is only 3.5 m long.

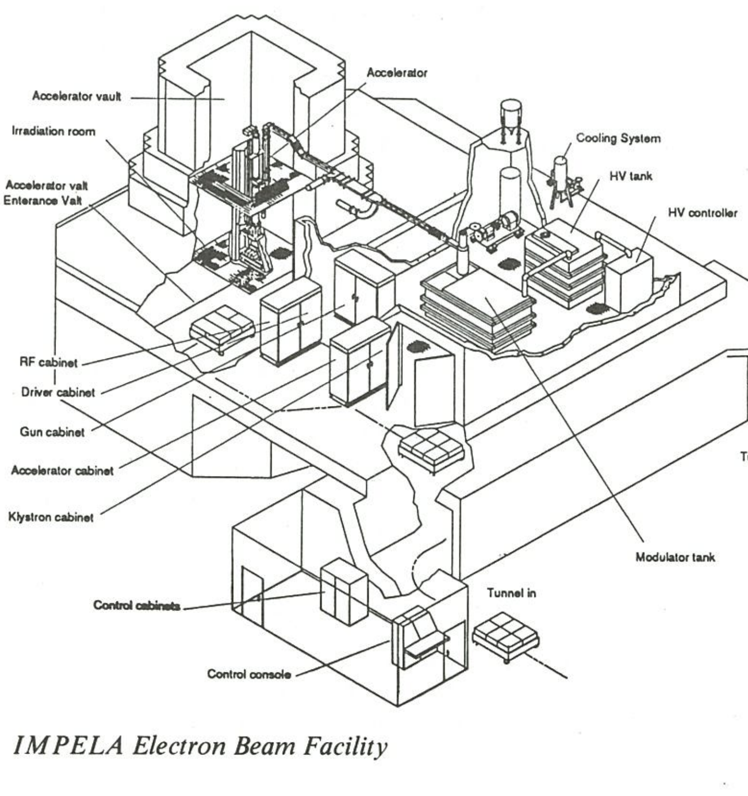
IMPELA uses an L-band, on-axis-coupled, standing-wave, cavity system for accelerating the electrons. The structure has a high shunt impedance which ensures efficient conversion of rf power to accelerating gradient and can be operated with high beam loading. Cooling channels for high power operation also permit rapid start-up.



Energy and power ranges of new and existing technologies

After exiting the accelerator the electrons are bent 270° to provide a beam perpendicular to the accelerator axis. The beam then passes through a diverging vacuum chamber (to spread the beam) which can be positioned as close as 15 cm to the product being irradiated.

E-Beam Services, Inc. provides contract radiation processing services. When the AECL IMPELA machine is installed in its New Jersey facility it will be used for processing medical devices, plastic parts, semiconductors and other products.



IMPELA Electron Beam Facility

Consultation?

Consultation and dialogue. These appear to be the key words for the nuclear community over the next few years, at least in the view of AECL President Stan Hatcher and some of his associates. Hatcher broached the theme in his address to the CNA/CNS Conference in June and now the two organizations are considering a multi-year, multi-million-dollar program to carry out the concept.

There is no doubt that more dialogue is needed with the very large segment of the Canadian public who are uneasy about the use of nuclear energy. Many are ill informed and most have negative perceptions influenced by the adverse images conveyed by those irreconcilably opposed to things nuclear (for whatever reason) and transmitted, amplified, by the media. There is, however, no point in attempting to "dialogue" with those anti-nuclear individuals or groups whose views appear to stem from a belief that anything "nuclear" is evil.

The thrust of the proposed program is to meet with tens of thousands of people across the country to discover, "what must the nuclear industry do to make nuclear acceptable". Teams of knowledgeable (and presumably convincing) representatives of the nuclear community would go out to meet with citizens representing different groups or constituencies, with the emphasis on dialogue.

Is such a "mini-Spicer" effort realistic? The strength of the Spicer exercise was that the commissioners just listened. They did not try to "dialogue" with the groups with whom they were meeting (although the individuals in the groups certainly dialogued extensively between themselves) nor did they try to explain or convince the participants of the virtues of our country or federal system. It is questionable if any group of Canadians care enough about the use of nuclear energy to debate with themselves.

If the missionaries of the nuclear industry enter the dialogue by explaining (from their "superior" knowledge) or gently persuading, the whole exercise will likely be perceived as just another (more subtle perhaps) attempt by the nuclear industry to manipulate public opinion. This perception will, almost assuredly, be enhanced when the public learns that the industry is pouring millions of dollars into the effort.

The public may be ill-informed but it is not stupid. Members of the public are unlikely to accept a claim by nuclear representatives that they want a fully unrestricted dialogue if the outcome might be a recommendation that nuclear energy should be phased out. It would be far better to be "up-front" and openly acknowledge that the hope, desire, objective of the program is that a significant percentage of the public will conclude that nuclear power, and other uses of nuclear energy, are acceptable. Otherwise the considerable sums involved will do little but finance the consultants involved.

Avoiding the unpleasant

One of the saddest, and potentially self-destructive, proclivities of the nuclear industry is the refusal to acknowledge problems openly. Even at the annual gathering of the clan there appears to be an unspoken agreement not to raise any unpleasant or difficult issues. Such was the case at this year's CNA/CNS conference. Despite the vital importance of the Darlington station not a word was spoken of the problems being encountered. Even in the technical sessions of the CNS – where open, professional discussion, which can lead to new insights and solutions, should be expected – the word 'Darlington' was rarely heard.

When members take part, explicitly or implicitly, in such a conspiracy of silence, the claim of the CNS to be a professional, scientific society is in jeopardy.

This issue

This issue was originally scheduled to be out in July and contain a full report on the 1991 CNS Conference. For a number of reasons such a report was not possible, requiring a revamping of plans with the attendant delays. Our apologies. We hope you enjoy the various articles nevertheless.

What we have is a potpourri of topics – consider it a summer smorgasbord.

The central article (or group of articles) concerns Chernobyl. Although more than five years have passed since that fateful April 1986 event the consequences and legacy of the world's worst nuclear accident continues to haunt us. Hopefully the information provided will be useful for your own understanding and for your discussions with others.

The second winning paper from the CNS Student Conference last spring is an excellent review of fission products in SLOWPOKE reactors. Like the undergraduate paper published in the last issue the quality of this paper attests to the high standards being achieved in our universities.

Although we do not have a technical report from the annual conference, we do have some notes on the annual meeting and some photographs (which, supposedly, are worth a thousand words).

With licensing and regulation becoming more and more significant factors in any nuclear project, John Graham's observations on the differences (and similarities) between those of the U.S.A. and Canada makes interesting reading.

And, of course, there is news of happenings in the Society (which, we can report, is alive and well!)

Chernobyl revisited

The serious accident at the Chernobyl power plant in the USSR in April 1986 remains the most negative picture of nuclear power in the eyes of the public throughout the world.

If the legacy of that disaster is to be overcome efforts must be made on many fronts. Some actions have been taken, such as the reviews of the design and operation of our nuclear power plants in the light of lessons drawn from Chernobyl. See, for example, AECB reports INFO-0234 and 234-1.

An on-going challenge for members of the nuclear community is to be sufficiently knowledgeable about the event to be able to counter mis-information with facts. If this is done consistently and honestly perhaps a more realistic evaluation and judgement of Chernobyl – and thereby of nuclear power – might evolve.

To that end, following is a report on the International Chernobyl Project which was concluded earlier this year.

Also of note is the CHERNOBYL BRIEFING BOOK. This is a 25 page compilation of data covering the accident itself, the differences between the Chernobyl RBMK reactor design and those of western nations, and actions over the intervening years to improve nuclear power plant safety in the USSR and around the world.

It was published by the CNA and the USCEA in April 1991 and is available from the CNA office.

The CNA also has available a VHS video (in English) entitled "Chernobyl as Viewed from the 90's" which was produced by the I.V. Kurchatov Institute in Moscow.

The International Chernobyl Project

Overview Report

The report of the International Chernobyl Project, subtitled "An Assessment of the Radiological Consequences and an Evaluation of Protective Measures", was presented to a special meeting held in Vienna in May. The full report runs to almost 900 pages in three volumes. An Overview was produced, of 57 pages. (We are indebted to Dr. Norm Gentner, of AECL's Chalk River Laboratories who was a member of the project team, for an early copy of the Overview.)

The International Chernobyl Project was an assessment of the radiological consequences of the radiation situation in three parts of the USSR affected by the release of radioactive material from the Chernobyl accident. The study, which was requested by the USSR, was coordinated by the International Atomic Energy Agency on behalf of a number of UN agencies and the Commission of European Communities. It was overseen by an International Advisory Committee of 21 and conducted by a team of 200 experts loaned by organizations around the world.

The Project assessed the situation in three affected Soviet republics – the Ukrainian Soviet Socialist Republic, the Byelorussian Soviet Socialist Republic, and the Russian Soviet Federated Socialist Republics. It did NOT make any assessment of the more than 100,000 persons evacuated from the most highly contaminated zone (30 KM around the plant) nor of the large numbers of emergency personnel brought in for accident management and recovery work.

The Project concluded that the dose estimates by Soviet authorities had been conservative and that, in general, the protection measures taken were reasonable. It noted that there were no health disorders (in the population surveyed) directly attributable to radiation exposure.

Following is a summary of the conclusions of the Overview Report (prepared by NucNet of the European Nuclear Society).

Summary of Conclusions

General Conclusions

- There were no health disorders that could be directly attributed to radiation exposure. There were no indications of an increase in the incidence of leukaemia and cancers.
- There were significant non-radiation related health disorders in the populations of both the surveyed contaminated settlements and control settlements.
- The accident had substantial negative psychological consequences in terms of anxiety and stress due to continuing and high levels of uncertainty, relocation and other measures.
- Early actions taken by the authorities – in cases which could be assessed by the project – were broadly reasonable and consistent with internationally-established guidelines.
- Protective measures taken or planned for the longer term, although well intentioned, generally exceed what would have been strictly necessary from the point of view of radiological protection.
- Official procedures for estimating doses were scientifically sound. The methodologies used were intended to provide results which would not under-estimate the doses.
- Measurements and assessments carried out under the project provided general corroboration of the levels of surface contamination for caesium as reported in the official maps made available to the project teams.

Health Impact

Conclusions

Reported adverse health effects attributed to radiation have not been substantiated by local studies which were adequately performed or by those of the project.

The psychological problems were wholly disproportionate to the biological significance of the radioactive contamination.

The consequences of the accident are inextricably linked with the many socio-economic and political developments that were occurring in the USSR.

A large proportion of the population have serious concerns. The vast majority of adults examined in both contaminated and control settlements either believed or suspected they had an illness due to radiation.

Relatively high infant and peri-natal mortality levels prevailed before the accident and appear to be decreasing. No statistically significant evidence was found of an increase in incidence of foetal anomalies as a result of radiation exposure.

Official data were not detailed enough to exclude the possibility of an increase in the incidence of some types of tumour.

Reported absorbed thyroid dose estimates in children are such that there may be a statistically detectable increase in the incidence of thyroid tumours in the future.

Future increases over the natural incidence of cancers and hereditary defects would be difficult to discern, even with large, well-designed and long-term epidemiological studies.

Many of the local clinical investigations had been done poorly, producing confusing, often contradictory results. This was due to a lack of well-maintained equipment and supplies, lack of documentation and lack of access to scientific literature, and a shortage of well-trained specialists.

Protective Measures

Conclusions

The relocation and food restrictions should have been less extensive. These measures were not justified on radiological protection grounds. However, any relaxation of the current policy would almost certainly be counter-productive in view of the present high levels of stress and anxiety. Many social and political factors have to be taken into consideration, and the final decision must rest with the responsible authorities.

The cautious approach of over-estimating doses was inappropriate in principle and contradictory to the fundamental objectives of intervention. This contributed to additional and unnecessary fear and anxiety in the population, and led to some people being relocated needlessly.

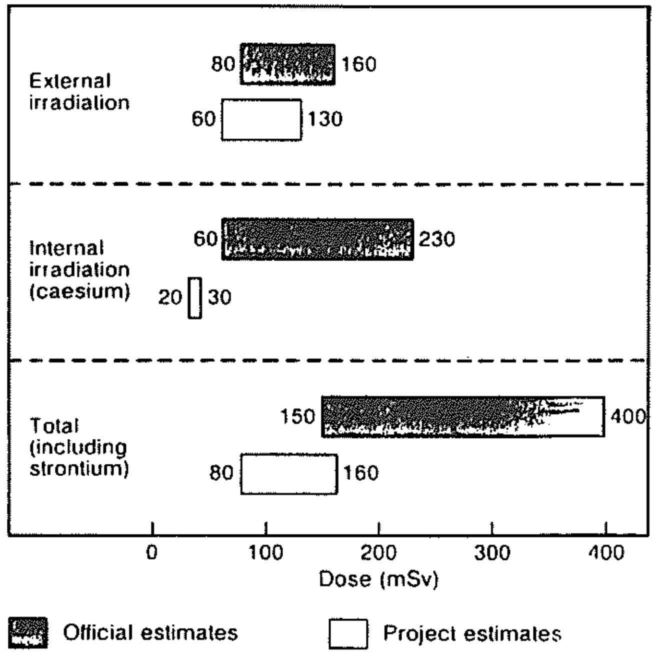
Background on the Project

The study involved five main tasks:

- a historical account of the major events leading up to the current radiological situation;
- corroboration of environmental contamination assessments;
- verification of individual and collective dose assessments;
- clinical health effects from radiation exposure and evaluation of the general health situation;
- evaluation of protective measures.

The project, carried out at the request of the Soviet government, ran from May 1990 until the end of last year. It involved about 200 independent experts from 22 countries and seven international organizations – the IAEA, the UN Scientific Committee on the Effects of Atomic Radiation (UNSCEAR), the World Health Organization, the Food and Agriculture Organization, the Commission of the European Communities, the World Meteorological Organization, and the International Labour Organization.

The complete series of conclusions and recommendations was approved by the project's International Advisory Committee in Vienna in March. Full details of the radiological and health assessments are contained in an 800-page technical report.



Comparison of project estimates and officially reported estimates for radiation dose to the population in selected settlements

Chernobyl history

Ed. Note: *Following is the history of the Chernobyl accident and subsequent events which was prepared by the International Chernobyl Project and appended to their Overview Report.*

Sources for this appendix include published material on the Chernobyl accident and the interviews conducted by Project experts with people living in the affected areas as well as with governmental officials and scientists. This portrayal is in no way intended to imply judgements based on hindsight or to detract from the courage of those who acted to save the lives of others, or to criticize those who made difficult decisions on the basis of limited information.

Emergency Actions at the Site

In the early hours of Saturday 26 April 1986, an accident which was to have global repercussions occurred at Unit 4 of the Chernobyl nuclear power plant in the UkrSSR. Seconds past 01:23 Moscow time, two explosions in quick succession blew the roof off the Unit 4 reactor building. Concrete, graphite and debris escaped through a hole which exposed the reactor core. Smoke and fumes along with a large amount of radioactive material rose in a hot plume almost 2 km high to be carried throughout the western portions of the USSR, to eastern and western Europe, and – in much smaller amounts – through the Northern Hemisphere. Heavier debris and particles fell near the site while lighter particles were carried west and north of the plant to the surrounding areas and neighbouring Soviet Republics.

Fires broke out on the roof of the adjoining turbine building. Fire, along with clouds of steam and dust, filled the Unit 4 building. Alarms went out to fire units in the region and within minutes plant firemen arrived. None of the firemen had been trained in fighting fires involving radioactive materials. Some set to work with plant personnel in the turbine hall and the Unit 4 building while others climbed to the roof of Unit 3, where they had to deal with burning graphite from the exploded core. By dawn on Saturday all but the graphite fire in the core had been extinguished.

"Initial reports of core destruction ... were not believed."

An explosion of this nature had not been considered possible by many Soviet nuclear experts and the initial reports of core destruction by workers who entered the Unit 4 building were not believed. Operators continued to direct water into the reactor building in a vain attempt to cool the reactor core and this contaminated water flowed to building levels that crossed to other units, causing later contamination problems.

Rescue workers, firemen and operating personnel were generally unaware of the seriousness of the radiation risk. The high radiation levels could not be measured with available monitoring equipment and in some areas must have exceeded 100 Gy/h. Personnel had no dosimeters to measure their radiation dose and many were serious irradiated. Less than an hour into the emergency the first case of acute radiation was evident. The number of persons present at the reactor site in the early hours of 26 April who showed clinical effects due to radiation exposure or burns was 203.

Signals indicating a serious accident involving an explosion, fire and radiation from Chernobyl were transmitted automatically to the State Committee on the Utilization of Atomic Energy in Moscow moments after the accident. As the information accumulated, even though the magnitude of the accident had not yet been fully established, it was decided to send key people from Moscow to direct operations. Top officials were called together as a Governmental Commission to provide the authority to mobilize resources. The plant management did not have the resources or authority to manage the response to an accident of this scale and it was the Governmental Commission itself that directed operations. Unit 3 was shut down around 03:00, an hour and a half after the accident, while Units 1 and 2 were not shut down until the following night, about 24 hours later.

Army forces were asked to carry out the first radiological assessment and to assist in controlling the fires. Early measurements showed neutron emissions, indicating continuing nuclear reactions in the destroyed Unit 4 core. As the accident would be more devastating if it spread to the other units, the Governmental Commission gave first priority to graphite fires.

The plant emergency plan was not suitable for an accident with large and continuous releases of radioactive material. Emergency facilities and emergency equipment were insufficient. There were no individual dosimeters for the emergency response units and no automatic radiation monitoring stations in the environs. Civil defence authorities specified possible shelters and proposed that the Pripyat town executive committee inform the population by radio of the radiation danger, but this was only done on Sunday just before the evacuation.

High radiation levels forced the Governmental Commission to move its headquarters from the town of Pripyat, 3 km from the reactor, to the town of Chernobyl, 15 km south-southeast of the plant, on 4 May. There were now thousands of people working on the site and the organizational responsibility to provide them with equipment and food was transferred to the Deputy President of the Council of Ministers of the USSR.

With the destroyed core open to the atmosphere, it was decided to cover the crater with heat absorbent and filtering materials. Airforce pilots flew hundreds of hazardous missions over the core, from 27 April to 10 May, in helicopters rigged to drop tonnes of boron, lead, clay, sand and dolomite.[6] A growing concern was the possibility that molten fuel would reach the water in the pressure suppression pools below the core, causing steam explosion and further releases. Under extremely difficult conditions and in a radioactive environment, military volunteers managed to rig up temporary piping to pump out water that had filled the normally dry second level. The command team also undertook the installation of a concrete slab underneath the damaged reactor to prevent any molten fuel from damaging the floor structure and leaking into the ground below.

Evacuation of the Prohibited Zone

Evacuating Pripyat

Early on Saturday 26 April the explosion and fire at the plant were reported to BSSR and UkfSSR and district civil defence authorities. Within hours, a UkrSSR headquarters had been set up in Pripyat and police established roadblocks to prevent all but emergency vehicles from entering. By noon, regular radiation monitoring had begun in and around Pripyat. The highest readings were found just to the west of the plant, but the wind was light, slowing the spread of radioactive material. Civil defence officials prepared for Pripyat's evacuation although only the USSR Government had the authority to initiate it.

By the evening, radiation levels were up to 1000 times natural background radiation (0.1 mSv/h) in Pripyat. Although the radiological situation was not yet considered alarming, the physicists on the Governmental Commission were recommending evacuation as they were uncertain about the condition of the reactor core and the future course of the accident. The Commission decided at about 22:00 to evacuate the population on the next day, 27 April. They contacted transport officials from as far away as Kiev and arranged for more than a thousand buses, which arrived throughout the night. Officials in the nearby towns of Polesskoe and Ivankov were alerted to prepare for receiving the evacuees.

Meanwhile, because of the obvious severity of the accident –

the explosion had been heard, smoke and fire were visible, civil defence forces were monitoring the city, injured were arriving at the hospital and plant workers had alerted their families and others – some officials took action on their own initiative. They warned others to stay indoors and distributed available potassium iodide tablets. Some teachers, recalling earlier civil defence training, cancelled Saturday outdoor events. They kept students indoors and attempted to prevent contaminated outdoor air from entering buildings. Other people decided to leave Pripyat by train or river boat before the service would be cut off, and those who could left by car before roadblocks would be in place.

"There were no warnings to stay indoors."

Officially, life in Pripyat was allowed to proceed more or less normally on Saturday. Steps were taken to prevent panic. Civil defence officials did not use face masks until after the evacuation as there had not been enough to supply the children. An amusement park which had been brought back into use only a few days before was open, with many people present. There were no official warnings or instructions to stay indoors and no systematic distribution of potassium iodide tablets.

At 07:00 on Sunday morning, 27 April, the head of the Governmental Commission confirmed the decision to evacuate Pripyat. He met with Pripyat town officials at 10:00 and instructed them to prepare for evacuation at 14:00. The nearly 1,200 buses assembled near the town of Chernobyl were set in motion in a line several kilometres long and the evacuation of Pripyat began at 14:00, just over 36 hours after the accident.

The number of people to be transported was less than the projected 44,600 as some had already left or were away for the weekend. There was adequate transport and the evacuation went smoothly. In less than three hours the city was emptied of all but those with official duties.

Expanding the evacuation zone

On 28 April, the civil defence authorities of the UkrSSR and the USSR proposed the establishment of a 10 km exclusion zone around the plant. On 2 May, high governmental officials arrived from Moscow. Prime Minister Ryzhkov, who could call upon the industrial resources of the USSR, created an operational group of the Politburo Central Committee to direct the national effort. Fundamental decisions could now be taken regarding necessary work as well as the contributions and participation required from organizations throughout the USSR.

On 2 May it was decided to evacuate people from a zone of 30 km radius around the reactor; this zone became known as the prohibited zone. The evacuation of the entire prohibited zone was completed on 6 May. It was an undertaking requiring transport of thousands of people and thousands of farm animals. The zone was fenced off and access has been controlled ever since. While the area still remains evacuated, numerous people enter and leave to work at the site and in cleanup and research activities in the town of Chernobyl. A substantial number of people who left their homes later returned surreptitiously and some families have reportedly been allowed to return in less contaminated southern areas of the zone. In addition to the 30 km prohibited zone, evacuations were carried out from territories east and west of the zone where radiation levels exceeded 50 μ Sv/h (5 mrem/h). On 10 May a dose rate map was drawn with isopleths: a rate of 200 μ Sv/h (20 mrem/h) formed the boundary of the prohibited zone (about 1,100 km^2 in area), 50 μ Sv/h (5 mrem/h) the boundary of the evacuation zone (3,000 km^2) and 30 μ Sv/h (3 mrem/h) the boundary of the strict controlled zone (8,000 km^2), from which children and pregnant women had to be temporarily evacuated. The maps of contamination by long lived isotopes prepared in June and July 1986 showed that resettlement had to be carried out from an additional 29 settlements in the BSSR and 4 in the RSFSR.

Securing the Site

It was necessary to isolate the destroyed and contaminated reactor building. Engineers decided on a structural covering with a span of 55 m that used remaining walls as supports. Design work and construction proceeded quickly, allowing Unit 4 to be enclosed inside a concrete and steel shell by mid-November 1986. In order to monitor conditions inside the structure, both gamma radiation and temperatures are measured in various locations. Approximately 96 per cent of the fuel remains in the reactor and the premises of Unit 4. A steadily decreasing gamma dose rate indicates that the fuel is in a stable condition.

Because of the difficult conditions under which it was built, as well as the need to ventilate it, the 'sarcophagus' was not sealed from the environment. Spaces exist between construction elements in the upper part of the structure and there are holes in the roof to provide natural convection inside. The spaces are monitored for radioactive measures.

Radiation Release and Transport

It is estimated that 25 to 50 million curies of radioactive elements were released from the reactor core. The intense heat increased the release of the volatile isotopes of iodine and caesium. There were approximately ten million curies of iodine released and approximately two million curies of caesium. The releases did not occur in a single large event. In the five days that followed the initial release, the release rate declined, reaching a minimum of approximately 15 per cent of the initial release rate. During the following four days the release rate increased to about 70 per cent of the initial rate. A sudden drop to less than 1 per cent of the initial rate then occurred, with a continuing decline thereafter.

During the first day, the plume above the plant reached 1,800 m. By the following day, the maximum height was 1,200 m, with the bulk of the material being released not exceeding 600 m. From the third day onward, the plume did not exceed 600 m. (The volatile elements iodine and caesium were detected at even greater altitudes of 6-9 km, with traces also in the lower stratosphere. The heavier elements, such as cerium, zirconium, neptunium and strontium, were of significance only in local deposition rates within the USSR.) At the time of the accident, surface winds were light and variable, but at 1,500 m altitude the winds were 8-10 m/s from the southeast. Material carried to this height was transported towards Finland and to Sweden, where radioactivity was first detected outside the USSR on 27 April. Moscow TV broadcast news of the accident on the evening of Monday 28 April.

By 7 May, maps of radiation levels over the European territory of the USSR were completed on the basis of data collected by aerial surveys. From then on, the USSR Hydrometeorology

Institute released data on a daily basis with forecasts of transfer trajectories at various altitudes which were transmitted to local authorities and to the Ministries of Health and Agriculture.

Protection of Rivers and the Kiev Reservoir

One of the more critical issues was the potential for contamination of the water system and from the first days after the accident, studies of water contamination were begun by the State Committee on Hydrometeorology. Monitoring of radionuclide concentrations in the area of the River Dnepr and its tributary the Pripyat indicated that contamination was principally from fallout since there was a sharp reduction in radionuclide concentration as the airborne contamination decreased.

In the very first days after the accident, estimates were made of the concentrations of radioactive contamination in water bodies due to the fallout and of projected concentrations if rainfall were to bring additional radioactive contaminants from the ground into the water system. Calculations showed that in the event of intensive rainfall in the vicinity of the River Pripyat, the concentrations of the most critical radioactive isotope ^{90}Sr would not exceed the limits set for drinking water by the USSR regulations, provided releases from the reactor would soon be terminated. Later measurements confirmed this forecast.

Owing to the heavy fallout in the immediate vicinity of the reactor, the nature of the soils in the area, and the direct connection through the nearby cooling pond to Kiev's principal reservoir on the River Dnepr north of Kiev, a good deal of effort was made to slow the movement of long lived radionuclides (such as ^{137}Cs and ^{90}Sr) through ground or surface water. There were three major undertakings. First, 140 dams and dikes were built to limit runoff from the site area into the cooling pond and the adjacent River Pripyat. Second, a series of existing silt traps at the bottom of the rivers, the pond and the reservoir were scoured. Third, an 8 km long barrier, 30-35 m deep, was built around the plant down to the impermeable clay layer to prevent the flow of radioactive water towards the River Dnepr.

Decontamination

After the major releases from the plant had subsided, decontamination was undertaken to reduce dose rates in areas from which the population had not moved. Primary attention was given to municipal buildings such as schools, nurseries and hospitals, while contaminated buildings of lesser importance were demolished and the waste buried.

At first, officials declared that much of the evacuated territory could be reoccupied after decontamination. However, in many cases decontaminated surfaces quickly became recontaminated owing to resuspension of radionuclides migrating from land, vegetation and structural surfaces. The most effective decontamination proved to be natural processes ('biological decontamination') such as decay and migration into the ground, and active decontamination work in most settlements has been discontinued.

Intervention Measures

After the initial evacuations, the USSR National Commission on Radiological Protection formulated intervention criteria for reducing exposure due to contaminated food and water. The main sources of exposure changed with time, as did the measures taken to control them. In the first few months, exposure was due to radioiodine in milk from cows that had grazed on contaminated pastures and this was dealt with through intervention measures such as the provision of potassium iodide and the supply of clean milk. At the same time, the problem of radioiodine and other nuclides deposited on fresh vegetables was addressed through intervention measures such as the supply of clean food. Over the long term, the principal exposure was due to ^{137}Cs in milk, meat and other foods and this was dealt with through intervention measures restricting food production and consumption, and changes in agricultural management.

Establishing the safe living concept

The radiation protection situation was complicated by the extent of the areas contaminated and the huge control programme necessary for measuring both environmental and food contamination. A number of safe living concepts have been proposed, including a temporary dose limit introduced during the first year, a lifetime dose limit concept, a two-tier lifetime dose limit concept, a dose rate concept and a surface contamination concept. The USSR Ministry of Health introduced a maximum temporary dose limit of 100 mSv (10 rem) for the first year after the accident. A set of additional temporary dose limits for the years 1987-1989 were later approved.

By early 1987, it became increasingly apparent that the food and behavioural restrictions were having a major impact on everyday life in the three Republics. Authorities recognized that the system of restrictions on farming in the predominantly rural, agricultural regions would not be satisfactory in the long term. In late 1988 they proposed a lifetime 'safe living concept' that was to define radiological conditions under which people were not subject to restrictions on their diet or lifestyle. This set the lifetime dose limit over 70 years from the time of the accident at 350 mSv (35 rem). The limit was an action/no-action level concept. The concept was approved by the Council of Ministers of the USSR in September 1988.

"The lifetime dose limit was ... seriously criticized."

By the beginning of 1989, however, the lifetime dose limit concept was being seriously criticized. Proponents of the concept argued that lower values would result in severe disruption as a result of excessive relocation. As a result of mounting criticism it was expanded to a two-tier system. This modified version included a lower level of lifetime dose (70 mSv or 7 rem) below which no action was to be taken. Between the lower and upper levels (still 350 mSv or 35 rem), varying measures would be introduced. Above the upper level, relocation remained compulsory.

In April 1990 the Supreme Soviet of the USSR introduced a surface contamination concept as a criterion for both relocation and payment of compensation. This divides the affected areas into three classes of zones (this was done despite the fact that there is no simple relationship between the surface contamination level and annual dose or lifetime dose because of differences in transfer factors, living conditions and eating habits): those with a surface contamination level of caesium above 40 Ci/km^2 (1,480 kBq/m^2); those with levels in the range 15-40 Ci/km^2 (555-1,480 kBq/m^2); and those in the range 1-15 Ci/km^2 (37-555 kBq/m^2). Relocation and other forms of compensation would depend upon which zone a settlement was in.

Best Postgraduate Paper

A Preliminary Investigation of Fission Product Release Behaviour in SLOWPOKE-2 Reactors

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Ed Note: *The following paper was judged the best paper in the postgraduate section at the CNS/CNA Student Conference held at RMC in March.*

The winning undergraduate paper was published in the spring issue of the Bulletin, *Vol. 12, No. 1.*

Abstract:

Increasing radiation fields due to a build-up of fission products in the reactor container water of SLOWPOKE-2 reactors fuelled with uranium-aluminide fuel have been observed. It is believed that these increases are associated with fuel fabrication problems where a small amount of uranium-bearing material is exposed to the coolant at the end-welds of the fuel elements. To investigate this phenomenon samples of reactor container water and gas from the headspace above the water have been obtained and examined by gamma spectroscopy methods at three reactors.

Introduction:

Following fabrication of the highly enriched uranium (HEU) fuel elements for the SLOWPOKE-2 research reactor, an external uranium contamination of the weld area was observed. This contamination probably occurred during the welding of end caps to the fuel pin meat, where some of the uranium aluminum alloy fuel was locally heated above its melting temperature and flowed out of the weld location. Although the weld area was machined later to remove such material, external contamination still remained[1] (see Figure 1).

In subsequent operation of several HEU-fuelled SLOWPOKE-2 reactors, radionuclides have been observed in the reactor container water that surrounds the fuel, but not in the pool water which, in turn, surrounds the reactor container. The gamma radiation fields about the reactor can generally be attributed to this buildup of radionuclides, although no radiological hazard has resulted. At present, the radiation fields at the SLOWPOKE-2 facilities at Ecole Polytechnique and the University of Toronto reach levels sufficient to activate the medium level radiation alarms positioned above the reactor container after only a few hours of reactor operation at high power. Although these alarms were initially installed to detect the loss of pool water shielding or maloperation of the control rod, they are now being triggered in the day-to-day normal operation of the reactors at which point the reactors must be shut down. While it is believed that the observed increases in radiation dose rates are associated with the above mentioned complication in fuel fabrication, it is necessary to establish whether there are any other contributing causes.

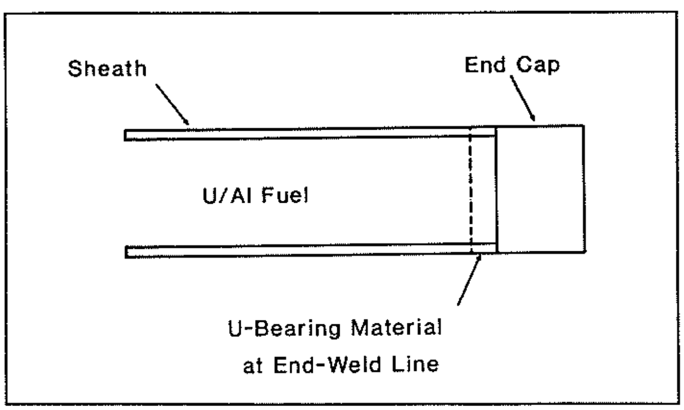

Figure 1: Diagram of a uranium aluminide fuel pin showing the approximate location of the exposed fuel.

By measuring the fission product release rates from the fuel to the reactor container water, it is possible to distinguish between release mechanisms and therefore to determine whether the increase in radiation fields around the reactor is due to external contamination of the fuel elements or due to a loss of integrity of the fuel sheath. This information can also be used to estimate the levels of activity to be anticipated in future operations of the lower-burnup cores.

This paper summarizes the experimental techniques, method of data analysis, and preliminary results to date at the SLOWPOKE-2 facilities at the Royal Military College (RMC), the University of Toronto (U of T), and at the Ecole Polytechnique (EP).

SLOWPOKE-2 reactor design:

The name SLOWPOKE is an acronym for *S*afe *LOW POwer* (*K*) critical *E*xperiment, a research reactor developed by Atomic Energy of Canada Limited. This reactor is inherently safe since increasing temperatures would produce a negative effect on excess reactivity.[1] The reactor produces a flux of 1.0×10^{12} neutrons/cm^{2}s and 20 kW of thermal energy at full power. Seven of these reactors are now operating across Canada and one is located at the University of the West Indies, in Kingston, Jamaica.

The SLOWPOKE-2 reactor is a tank-in-pool type of design[2] with a light-water moderated core within a reactor container structure (see Figure 2). The surrounding pool of light-water serves as radiation shielding for research personnel and also as a secondary heat sink. Water purity is maintained by circulating the container water through a series of deionizer columns on a weekly basis. Control of the reactor is maintained with a single control rod. The radiation monitors are located just above the reactor container (the medium-level alarm), above the reactor on he ceiling of the room (the area alarm), and beside the deionizer column (low-level alarm). Generally, only the medium-level alarm prohibits continuous full-power operation.

Fuel Design

Of the eight operating SLOWPOKE-2 reactors, seven were fuelled with 93% U-235 enriched uranium aluminum alloy fuel pins coextruded with aluminum cladding. The most recently commissioned SLOWPOKE-2 reactor (which is operating at RMC) is fuelled with low enriched uranium oxide fuel (20% U-235) to conform with international non-proliferation agreements to restrict the use of HEU fuel. The LEU fuel is clad in Zircaloy-4. A comparison of the two types of cores is given in Table 1. Radiation fields associated with fission product release from these cores have been observed only at those reactors fuelled with the HEU fuel.

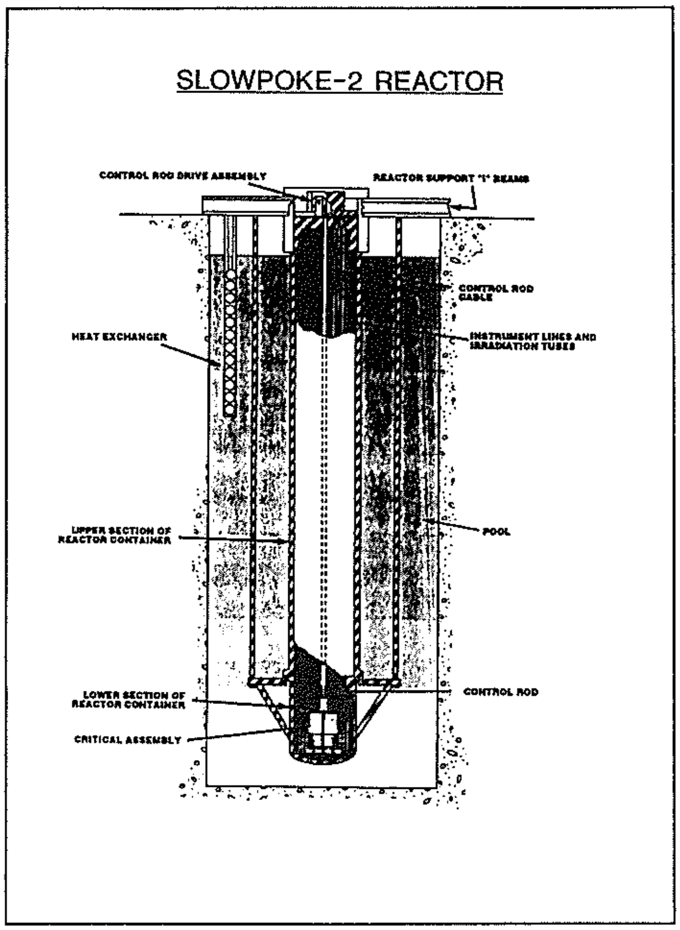

Figure 2: Reactor General Assembly (Taken from Reference 2)

Equipment:

An analysis of fission products in the reactor container water and gas headspace at three SLOWPOKE-2 reactors has been performed by gamma ray spectroscopy methods. A GMX high purity germanium detector with a thin beryllium window

Table 1. A comparison of SLOWPOKE-2 HEU and LEU cores (from Reference 3)

	HEU Kanata Isotope Production Facility (KIPF)	LEU (RMC)
Material	28 wt % U 72 wt % Al	UO_2
U-235 Enrichment (%)	93	19.89
Cladding	Al	Zr-4
Number of fuel pins	317	198
Total mass of U-235 (kg)	0.87	1.12
Density (kg m^{-3})	3.45×10^3	10.6×10^3
Specific Heat (J kg^{-1} K^{-1})	683	236.4
Thermal Conductivity (W m^{-1} K^{-1})	171	4.67

(EG&G Ortec) was used to detect photons with energies between 80 and 2500 keV. For ease of portability, the detector bias supply (-3000 V), signal amplifier, and analog to digital converter (ADC) are integrated into one self-contained instrument, the Canberra model 1510. From the ADC, the signals are passed on to a Canberra S100 (386) multi-channel analyzer (MCA) which is resident on a printed circuit board inside an IBM PS/2 P70 portable computer. Control over the MCA is obtained via a Windows 3.0 driven software package supplied by Canberra-Packard. The pile-up rejection feature of the ADC was not used since the dead time of the water and gas samples was low.

Radiation shielding of the detector was provided by a transportable ensemble consisting of a lead brick castle supported by a sturdy aluminum frame. Both the lead bricks and the structure may be disassembled in less than one-half hour and placed in their respective shipping containers for transit in a panel van. Background levels over the 2500 keV range were reduced to 180 counts per minute by the 10 cm thick lead bricks and a series of cadmium, copper, and Plexiglass liners.

The detector was calibrated using a standard mixed radionuclide solution QCY.46 obtained from Amersham International plc diluted with a carrier solution N.441 to the containers of the same shape and size as the sample vessels. An adjustable sample holder, which fits over the detector upon which any combination of six segments can be stacked, was used to increase the distance from the sample to the detector as the activity levels increased during the week of experimentation, while maintaining a reproducible geometry.

Data analysis:

A typical spectrum of the University of Toronto reactor water is shown in Figure 3. The activity of an isotope is calculated by dividing the total number of counts S contained in a photo-peak received, by the count time t_c. The program MicroSAMPO was used to calculate the photo-peak area for a given isotope from a gamma-ray spectrum.

If the count time is long compared to the half-life of the isotope, the isotopic activity at the commencement of the count is determined by:

(1) $$A(t) = S\,\lambda\;/(1-e^{-\lambda t_c})$$

The decay of the sample during the delay t_d between the time of sampling (t_s) and the time of counting was corrected for with the relation:

(2) $$A(t_s) = A(t)\,e^{\lambda t_d}$$

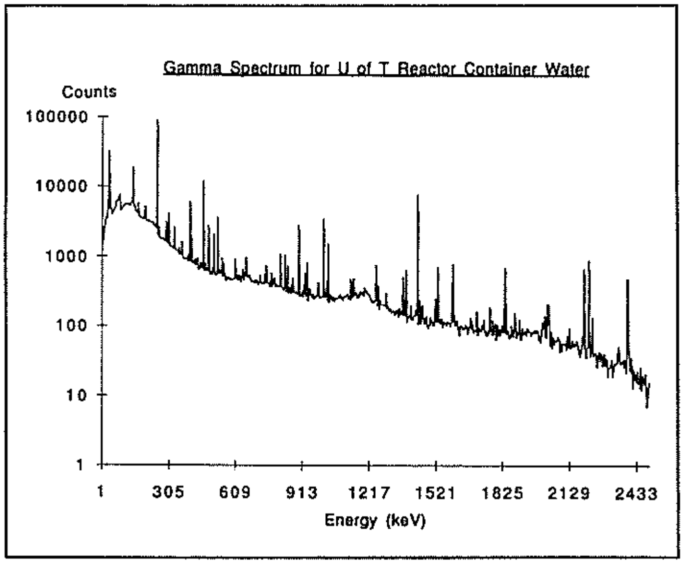

Figure 3: A typical gamma ray spectrum of a 40 mL sample of U of T reactor container water, counted for 25 minutes.

Experimental Procedure:

Reactor Operation:

The three reactors were run continuously at one-quarter power, producing a flux of 2.5 x 10^{11} neutrons/cm^2s for approximately 100 h to allow the long-lived fission products to reach equilibrium in the reactor. The reactor was operated at this low power to maintain an excess reactivity.

The radiation alarm levels were monitored throughout the week so that once the results of this study are known, these levels can be correlated with the fission product inventory in the reactor water. The outlet temperature of the reactor water was also recorded, since the solubility of the noble gases is a strong function of temperature as is the rate of deposition of the non-volatile fission products.

Initially, before the reactor was turned on, the reactor container water was run through the deionizer column, as per normal weekly maintenance, to remove any fission products present in the water which had been produced during the previous week of reactor operation. A sample of the water was examined and its spectrum recorded. The gas headspace was purged (also part of the weekly maintenance routine) several times until the amount of radioactive isotopes remained constant, and a final spectrum was saved to provide a baseline measurement.

Sampling Procedure:

For the sampling procedure of the gas headspace and the reactor container water, it is of particular concern that a representative sample be obtained. It is hoped that during the sample collection the system under study is not radically disturbed. If this is unavoidable, then the system must be disturbed in a consistent manner so that such effects can be corrected for later.

Gas Sampling Procedure:

Each SLOWPOKE-2 reactor is equipped with a closed sampling line and pump for the measurement of any hydrogen in the gas headspace. In order to obtain a uniform and well-mixed fission-gas sample, the gas pump was switched on for 10 minutes to recirculate the gases, after which it was switched off and the sample counted. A range of recirculation times was experimented with, from two to twenty minutes but similar results were obtained for the various isotopic concentrations.

Water Sampling Procedure:

The SLOWPOKE-2 reactor water purification system has a bypass loop through which one can obtain samples of reactor container water. In obtaining water samples, the pump (which has a flow rate of approximately 8 litres per minute), was run for two minutes in order to clear the dead space in the sampling line. At RMC the water sample was obtained in an open graduated cylinder and then decanted into a Marinelli beaker. During this transfer, some degassing had occurred (see Table 2). As such, the sampling procedure was modified for the U of T and EP experiments with the use of a sealed, pressurized sample chamber connected in line with the sampling port.

Transport Time Calculation:

There is a delay between the creation of fission products in the core and their uptake at the sampling port. During this transport time, the activity of the short lived isotopes will have decreased, and must be corrected for. The transport time was estimated to be thirteen minutes based on the time lag between the start-up of the reactor and the first appearance of the Xe-138 at the sampling port.

Table 2. Xe-133 concentrations (MBq/L) after 100 hours of operation at 5 kW (one-quarter power)

Reactor	Water	Gas
RMC *	1.9 x 10^{-5}	1.4 x 10^{-5}
U of T	1.5	0.27
EP	0.78	0.14

* *note: the ratio of the concentration of Xe-133 in the RMC reactor water to that in the gas is lower than expected (as compared to the ratio for the U of T and EP data) due to degassing during transfer of the water.*

Preliminary Results:

A list of activation and fission products observed in the reactor container water at U of T are given in Tables 3a and 3b respectively. In practice, only the noble gases remain as they are created in the reactor container water or in the gas headspace; consideration of the other fission products, such as the halogens and heavy metals, which may react to form compounds or precipitate out, would greatly complicate the analysis. At this stage in the investigation only the concentrations of the noble elements were determined. The species listed are representative of those observed at all three reactors, with the exception of Np-239, which was not seen in the water at EP. At RMC, this isotope is seen in conjunction with the activation product U-239.

The most significant difference between the various reactors is the absolute activity concentrations of the reactor water and gas as shown in Table 2. This table gives the absolute activity concentration of Xe-133 after 100 hours of continuous reactor operation at one-quarter power. The activity at the RMC reactor, which is fuelled with uranium dioxide fuel, is approximately five orders of magnitude less than that at the other two reactors which are fuelled with the uranium aluminide fuel that has the exposed uranium-bearing end-welds. The fission products observed at RMC are most likely due to surface contamination.[3] Activity levels at U of T are approximately twice those at EP, which is most likely due to the larger number of flux hours accumulated (105,000 flux hours at U of T compared to 74,000 flux hours at EP).

TABLE 3: IDENTIFICATION OF RADIONUCLIDES BY GAMMA-RAY ANALYSIS OF REACTOR CONTAINER WATER AT THE UNIVERSITY OF TORONTO

(a): Activation Products

Ar-41
Na-24
In-110m
Ag-110m
Np-239
U-239

(b): Fission Products

Kr-85m	Xe-137
Kr-87	Xe-138
Kr-88	Xe-139
Kr-89	I-131
Rb-88	I-132
Rb-89	I-133
Y-91	I-134
Sr-91	I-135
Zr-95	Cs-138
Mo-99	Cs-139
Tc-99	La-140
Te-132	La-142
Xe-133	Ba-140
Xe-135m	Ce-141
Xe-135	Ce-143

Model Development:

When a fission fragment is created from the splitting of a U-235 nucleus, it is highly energetic (typically 80 MeV) and can travel up to 30 μm before coming to rest in the fuel matrix where it would normally be contained (see Figure 4). If, however, the fission product is created within 30 μm of the surface of some exposed portion of the fuel (such as the uranium-bearing end weld line) it can be instantly ejected directly into the surrounding coolant. Such a release can thus occur by direct fission *recoil.* Alternately, a fission product created deep inside the fuel matrix will lose its kinetic energy within the same average 30 μm range, following which it may slowly migrate or *diffuse* through the fuel matrix, and escape once it reaches the exposed surface.

Since recoil release is an instantaneous process, the release rate (R_{fw}) from the fuel to the water (i.e. the coolant) is independent of the fission product half-life so that[4]

(3) $$R_{fw} = 0.25\ \mu\ (S/V)(\Delta S/S)\ F\ Y$$

where R_{fw} is the release rate (atoms per second) from the fuel to the water, S/V is the geometrical surface to volume ratio of the fuel element, μ is the average range of the fission fragment in the fuel, $\Delta S/S$ is the fractional surface area of the fuel exposed to the coolant, Y is the fission yield for the radionuclide of interest, and F is the fission rate.

On the other hand, the release rate for the diffusion process will depend on the half-life in the following manner, according to the Booth diffusion model[5]:

(4) $$R_{fw} = (\Delta S/S)\ 3\ (D_f'/\lambda)^{1/2}\ F\ Y$$

where D_f' is an effective diffusion coefficient for fission products in the fuel matrix, and λ is the decay constant. A log-log plot of the release rate as a function of λ will thus display a slope of -½ for a diffusion process and a flat horizontal line for a recoil process.

Unfortunately only the activity concentrations of the fission products can be measured. Using mass balance equations[6], the release rates can be determined from the activity concentrations. The net rate of change of the number of atoms of a certain radioisotope in the water (N_w) is

(5) $$dN_w/dt = R_{fw} - \lambda N_w - R_{wg}$$

where R_{fw} is the release from the fuel to the water, λN_w is the rate of loss due to radioactive decay, and R_{wg} is the release rate from the water up into the gas headspace.

The complementary equation for the gas headspace is

(6) $$dN_g/dt = R_{wg} - \lambda N_g$$

where N_g is the number of atoms of the same radioisotope in the gas headspace, R_{wg} is the rate of release from the water to the gas headspace, and λN_g is the rate of loss due to decay. These two coupled differential equations can be rearranged and release rates can be obtained as a function of the activity concentrations C knowing the volume V of the water and gas in the reactor container, so that

(7) $$C = \lambda N/V = A(t_s)/(\epsilon\ V_s I),$$

where $A(t_s)$ is the measured activity of the sample corrected for decay during the period prior to counting, ϵ is the efficiency of the detector at the energy of the emitted gamma ray and for the specific sample geometry, V_s is the volume of the sample container, and I is the absolute gamma intensity for each decay.

Release Mechanism:

Since the reactors had been operating for 100h, isotopes with short half-lives will have reached equilibrium by the end of the experiment. When the concentration of fission products has reached equilibrium in the reactor water, the term on the left hand side of Equation (5) will be zero. If the release rate from the water to the gas headspace is negligible compared to the release rate from the fuel to the water, i.e. $R_{wg} << R_{fw}$, then the release rate from the fuel to the water is given by the total activity of the reactor water:

(8) $$R_{fw} = \lambda N_w$$

In Figure 5, the activity concentrations of several noble gases in the reactor water at U of T have been plotted as a function of their decay constants. The concentrations have been normalized by the cumulative yield of each isotope. The short-lived isotopes have been corrected for losses due to decay as a result of the transport time from the core up to the sampling port. The long-lived isotopes such as Xe-133 and Xe-133m have not reached equilibrium in the water by the end of the week, and so the values have been extrapolated to equilibrium. From inspection of the curve, it is apparent that the release rate from the fuel is independent of the half-life of the isotope, which is consistent with a recoil release. Similar curves have been plotted using RMC and EP data although the release rates are several orders of magnitude smaller for the RMC reactor.

Conclusion:

Based upon the equilibrium concentrations of noble gas fission products in the reactor water at U of T and EP it is currently believed that the fission products found in the reactor container water are being released by a direct recoil process from an area of exposed uranium-aluminide fuel. Since the concentration of fission products has been increasing over the years[7] it is possible that a larger surface area of the fuel is being exposed to the coolant with time.

Future investigations:

Similar data will be obtained at the SLOWPOKE-2 reactor of the Kanata Isotope Production Facility this spring. It is hoped that by obtaining release rates for several reactors with different stages of burnup, predictions of future activity levels can be made. In addition, a visual inspection of an uranium aluminide fuelled core using an underwater camera is planned, and should provide additional information about the condition of the fuel.

Acknowledgements:

The contributions of my two supervisors, Dr. B.J. Lewis and Dr. L.G.I. Bennett, to this project must be acknowledged; not only for the weeks of experimentation and data collection in which they cheerfully participated, but for their advice in the preparation of this report and their continuing encouragement.

I also wish to thank Dr. R.G.V. Hancock, SLOWPOKE Reactor Facility, University of Toronto, and Dr. G.G. Kennedy, Laboratoire Polyfonctionnel SLOWPOKE, Ecole Polytechnique for their hospitality during the weeks of experimentation at their facilities.

Funding for this project has been provided by the Atomic Energy Control Board under contract no. 2.197.1.

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Technical Note

New dose limits proposed

The Atomic Energy Control Board proposes to reduce the radiation dose limit for workers from 50 mSv/yr to 20 mSv/yr and that for members of the general public from 5 mSv/yr to 1 mSv/yr.

The proposals are presented in AECB Consultative Document C-122, "Proposed Amendments to the Atomic Energy Control Regulation for Reduced Radiation Dose Limits Based on the 1991 Recommendations of the International Commission on Radiological Protection," issued July 19.

C-122 proposes new dose limits for both the public and workers, which will be consistent with the new recommendations of the International Commission on Radiological Protection (ICRP).

The AECB is distributing C-122 to all licensees, interested organizations, labour unions, members of the public and to the appropriate Provincial and Federal Government Departments. This document may be ordered free of charge from the Office of Public Information, Atomic Energy Control Board, P.O. Box 1046, Ottawa, Ontario, Canada K1P 5S9.

All comments received before October 31, 1991, will be considered in the revision of the document, prior to its use in the nuclear regulatory process.

Ed. Note: *Following are excerpts from AECB Document C-122.*

1. Introduction

The International Commission on Radiological Protection (ICRP) recently published ICRP 60, which contains new recommendations on radiation protection. These recommendations are based on the latest radiation risk estimates derived from the reanalysis of the atomic bomb survivor data and other epidemiological studies. The new risk estimates are significantly higher than those used by ICRP in 1977 for its recommendations contained in document ICRP 26 which form the basis for the last revision to the *Atomic Energy Control Regulations,* known as the "General Amendments."

The AECB proposes to revise the *Atomic Energy Control Regulations,* as soon as possible, taking the recommendations into account. ... The AECB invites comments by licensees and any interested members of the public on these proposed changes. ... This document does not contain the actual legal wording of the changes, but gives them in descriptive terms. Comments received will be used to develop the final legal wording which will appear when the proposed changes to the Regulations are published in the *Canada Gazette* Part I. A second period for comment will then be provided to licensees and the public before the Regulations become law by appearing in the *Canada Gazette* Part II. If significant modifications are made to the proposal as a result of comments received, provision will be made for further consultation on these modifications.

2. Proposed Revisions to the *Atomic Energy Control Regulations*

2.1 Individual Limits for Occupational Exposures

2.1.1 Atomic Radiation Workers

Workers who currently do not have a reasonable probability of receiving more than 5 mSv per year while working under the auspices of an AECB licensee are not considered as atomic radiation workers (ARW). This definition is based on the current public dose limit of 5 mSv per year. The AECB is proposing to adopt the ICRP recommendation of 1 mSv per year for the public, and therefore an atomic radiation worker will be defined as a worker with a reasonable probability of receiving more than 1 mSv per year. ... As a result of this changed definition, some workers will become atomic radiation workers who previously were not. This should not be construed as a relaxation in dose control for them (i.e., their dose limit changing from 5 mSv to 20 mSv per year). It is the intent of AECB to examine closely the way in which licensees apply the ALARA principle to their operations, to ensure that workers not now exposed to annual doses greater than 5 mSv do not have their exposures increased without good justification.

2.1.2 Effective Dose, Including That Committed from the Intake of Radioactive Material

For the occupational limit of effective dose the AECB proposal is a limit of 20 mSv in a dosimetry year.

The AECB proposes to allow for flexibility of implementation by means of a phasing-in period, and by specifying only an annual limit (i.e., removing the existing quarterly limit). This is in keeping with the ICRP recommendations, which do not propose the use of time periods of less than a year for control purposes. Moreover, the basis of the dose limit is lifetime risk, which does not appear to be affected by the rate at which the dose is accumulated.

Effective dose includes the dose from external radiation sources and from intakes of radioactive material. For the latter, the ICRP has published new annual limits on intake (ALI) in ICRP 61, based on a committed dose of 20 mSv from one year's intake, and these values may be used by the licensees.

2.1.3 Radon and Thoron Daughters

The new ICRP recommendations do not provide revised radon-and-thoron-daughter exposure limits although new recommendations on this topic are being developed. Meanwhile the ICRP has stated that the recommendations in ICRP 47 remain valid. ICRP 47 includes the annual limits for radon and thoron daughters, 4.7 WLM and 14.1 WLM respectively, which are the same as those in the General Amendments, and so there will be no change.

2.1.4 Aggregate Dose

The inclusion of radon-and-thoron-daughter exposures and intakes of other radioactive material in aggregate dose is accomplished by the following "combining formula." This is the same as proposed in the General Amendments except for a change from 50 mSv to 20 mSv in the first denominator, and the use of the new annual limits on intake from ICRP 61, based on a committed dose of 20 mSv, in the fourth denominator:

$$\frac{\text{External Dose}}{20\,\text{mSv}} + \frac{\text{Radon Daughter Intake}}{4.7\,\text{WLM}} + \frac{\text{Thoron Daughter Intake}}{14.1\,\text{WLM}} + \frac{\text{Radioactive Dust Intake}}{\text{ALI}(20\,\text{mSv})} \quad 1$$

The formula implies an equal risk from each denominator and requires that the total risk does not exceed that from 20 mSv of gamma radiation alone.

2.1.5 Skin Dose

The limit for skin is set by reference to deterministic (formerly known as non-stochastic) effects. These are effects such as reddening or ulceration of the skin which vary in intensity in proportion to the dose, and also have a threshold dose below which no effects appear. The proposed limit, which is below the threshold, is 500 mSv in any dosimetry year, averaged over any 1 cm^2 area at a nominal depth of 7 mg cm^2, regardless of the area exposed....

2.1.6. Hands and Feet

The proposed limit for hands and feet is 500 mSv in any dosimetry year, which is based on the avoidance of deterministic effects....

2.1.7. Lens of the Eye

The dose to the lens is limited by the risk of cataracts, which is another deterministic effect. The proposed limit is 150 mSv in any dosimetry year....

2.1.8 Other Tissues or Organs

Deterministic limits for other tissues such as bone surfaces are no longer needed because new information, largely from radiotherapy patients, shows that the effective dose limit of 20 mSv per year divided by the tissue weighting factors will ensure that doses are below the threshold for deterministic effects for any individual organ or tissue.

2.1.9 Occupational Limit for Pregnant Women

Dose limitation for the foetus is designed to minimize the risk of mental retardation, which has been seen in the offspring of some of the atomic bomb survivors. There is also thought to be a small risk of childhood leukaemia from exposure *in utero*. Currently available dosimetry techniques are unable to measure the dose to the foetus, and therefore this dose must be inferred from the dose to the woman. The AECB is therefore proposing the following:

> "Once a woman has declared her pregnancy, her dose for the remainder of the pregnancy is limited to 2 mSv from external sources, measured at the surface of her abdomen. This is assumed to give about 1 mSv to the foetus. For internal sources the exposure is limited to an intake of 0.05 ALI (Annual Limit on Intake), which is also assumed to give a maximum of about 1 mSv to the foetus."

The intention is to provide more protection to the foetus, approaching that given to a member of the public, while at the same time recognizing the limited period (nine months) of possible exposure *in utero* compared to the possible 70 years or more exposure period of an adult. It will be necessary for licensees to ensure that adequate dosimetry for the pregnany woman is available to demonstrate compliance.

2.2 Individual Limits for Members of the Public

2.2.1 Effective Dose

The ICRP based its recommendations for the public dose limit on a comparison with natural background rates, which are generally about 2 mSv per year, including doses from naturally-occurring radon daughters. A projection of lifetime risk of fatal cancer was also considered, which is about 1:10,000 for 1 mSv per year for 70 years. The ratio of new limit to old is 1/5 for the public compared to 20/50 for workers. This difference may be accounted for by the fact that public exposure is for 70 years compared to 50 years for workers, and that children, with greater radiation sensitivity, are included in the general public but not in occupational groups.

The AECB proposal is a limit for members of the public of 1 mSv effective dose per year.

The ICRP has recommended that in special circumstances this may be averaged over five years. The AECB does not intend to include such a provision in the Regulations. ... The operating levels for emissions from nuclear facilities will have to be reassessed by licensees by applying the ALARA principle, using the detriment associated with the new risk factors....

2.2.2 Skin Dose

The proposed skin dose limit for members of the public is 50 mSv per year.

2.2.3 Lens of the Eye

The proposed dose limit for the lens of the eye for the public is 15 mSv per year. ... The deterministic limits for skin and the lens of the eye are lower for the public than for workers because of the longer exposure period and the wider range of sensitivity when the whole population is considered.

2.3 ALARA Principle (As Low As Reasonably Achievable)

In developing a radiation protection programme the ALARA principle must be applied. All occupational doses above 20 mSv must be brought below 20 mSv regardless of the cost. Once this has been achieved, the ALARA process must be applied to reduce doses further. Since the risk per sievert is now considered to be greater than its former value, the detriment against which expenditure on protection is judged in the application of ALARA, will likewise increase. For the purposes of the new Regulations, the increase can be taken to be a factor of 2.5, which is the ratio of the old and new occupational limits on effective dose. All previous ALARA analyses must therefore be reviewed to take these changes into account....

3. Implementation

3.1 Occupational Dose Limits

... A phasing-in period will be allowed all licensees to meet the new occupational limits. Licensees who are not currently meeting the new dose limits for all individual atomic radiation workers will need to develop and implement measures to reduce doses to below the new limits, irrespective of the cost, and must have achieved this objective by January 1, 1995. Licensees must also review their ALARA analyses for occupational exposures and have implemented the resulting adjustments to their operations by January 1, 1995. Any new facilities (including those using radioisotopes) now at the design stage must be designed with 20 mSv per year as the occupational dose limit, so that the new regulations can be met when they come into effect.

During the phasing-in period the limits for atomic radiation workers in the current *Atomic Energy Control Regulations* or the General Amendments, whichever are in force, will apply, but any individual dose greater than the proposed new limits will require the licensee to demonstrate that steps are actively being taken to ensure that these new limits will be met by January 1, 1995. Licensees' progress towards meeting both objectives (i.e., dose limits and ALARA) will be monitored and progress reports may be required at the time of licence renewal, or at other appropriate times within the phasing-in period.

3.2 Dose Limits for Members of the Public

With regard to doses to the public, licensees will be given until January 1, 1993 to meet the new public dose limits. ...

TABLES OF DOSE LIMITS

Table 1. Stochastic dose limits

CATEGORY		CURRENT REGULATIONS AND GENERAL AMENDMENTS	C–122
Worker	Annual Limit	50 mSv	20 mSv
	Quarterly Limit	30 mSv	none
Public	Annual Limit	5 mSv	1 mSv
Pregnant Woman	Remainder of term	10 mSv to fœtus (0.6 mSv / 2 weeks)	2 mSv (abdomen) + 0.05 ALI

Table 2. Deterministic dose limits

ORGAN OR TISSUE		CURRENT REGULATIONS Quarterly Limit	Annual Limit	GENERAL AMENDMENTS Quarterly Limit	Annual Limit	C–122 Annual Limit
Lens of the Eye	Worker	80 mSv	150 mSv	80 mSv	150 mSv	150 mSv
	Public	—	15 mSv**	—	50 mSv**	15 mSv
Skin	Worker	150 mSv	300 mSv	300 mSv	500 mSv**	500 mSv
	Public	—	30 mSv	—	50 mSv**	50 mSv
Hands and Feet	Worker	380 mSv	750 mSv	300 mSv	500 mSv**	500 mSv
	Public	—	75 mSv	—	50 mSv**	—

** Any organ or tissue.

Leukaemia study

AECB issues report on childhood leukaemia around nuclear facilities

Ed. Note: *The following is reprinted from the "AECB Reporter," published by the Atomic Energy Control Board.*

With the publishing of the report *Childhood Leukaemia Around Canadian Nuclear Facilities – Phase II,* the Atomic Energy Control Board (AECB) has completed the second phase of a major study to investigate the incidence and mortality of leukaemia in children living around major nuclear facilities in the province of Ontario.

It can be concluded that: (1) while the rate of occurrence of childhood leukaemia around nuclear facilities may be higher or lower than the provincial average, there is no statistical evidence that the difference is due to anything but the natural variation in the occurrence of the disease; and (2) the rate of occurrence of childhood leukaemia around the Pickering nuclear power station was slightly greater than the Ontario average both before and after the plant opened, but this, too, could be due to the natural variation.

Reason for study

The study was commissioned by the AECB after studies in the U.K. noted an increased number of leukaemia cases in children living near certain nuclear facilities. In particular, five cases of fatal leukaemia were observed in children born near Sellafield, a nuclear reprocessing plant in northern England, where the number expected from national cancer rates was 0.53, a ninefold difference. Since radiation is one of several known causes of leukaemia, although the Sellafield phenomenon could not be explained on the basis of the low public radiation doses attributable to the plant, some exploratory research in the vicinity of Canadian nuclear facilities was considered prudent.

Areas examined

Canada does not possess any reprocessing plants, where highly radioactive used reactor fuel is chemically treated to separate some of its reusable components, but the populations around a variety of other kinds of nuclear facilities were investigated. Those selected were all in Ontario and have had a relatively long period of operation: the nuclear generating stations at Pickering and Bruce (Douglas Point); the uranium mines and mills at Elliot Lake; the uranium refining facility at Port Hope; and the nuclear research laboratories at Chalk River, along with the small nuclear power plant in nearby Rolphton.

Researchers

The study was conducted by Dr. E.A. Clarke and Dr. J. McLaughlin of the Ontario Cancer Treatment and Research Foundation, Toronto, and Dr. T.W. Anderson, of the University of British Columbia. The progress and final report of the study were scrutinized by an independent review panel of experts.

Scope

Information on leukaemia cases was obtained from the records of the Ontario Cancer Registry, one of the largest population-based cancer registries in the world. In the second phase of the study, records were examined for children up to 14 years old, in order to obtain a larger number and hence more accurate results compared to the first phase which only included cases up to age five. The study identified children who died from leukaemia between 1950 and 1987, and children who were diagnosed with the disease between 1964 and 1986. Their residence at birth and death came from birth and death certificates.

The researchers compared the number of observed cases around each facility to the number expected in a population of equivalent size based on the Ontario average. This was done for two geographic areas – the region within 25 km of each facility, and the county in which it is located. Comparisons were made for both death from leukaemia and diagnosed cases of the disease.

The study also looked at childhood leukaemia in the vicinity of the Pickering Nuclear Generating Station both before and after the plant began operating in 1971.

Method

In this study, a statistical test compared the observed number of cases (O) in a group to the number expected (E) in that group if the rate was the same as in the general population of Ontario, i.e. the provincial average. The comparison was given as O divided by E, (O/E). This would be a value smaller than one if the observed number of cases was less than the provincial average, and larger than one if it was greater.

With a rare disease like childhood leukaemia, the rate of occurrence observed in a population will vary from one period of time to another. For a given population, there is a minimum and maximum value within which the observed number is likely to fall each time it is counted. So that a statistician can tell that an observed value is or is not out of the normal range, a calculation is done to find out what that range might be.

In this study, the researchers calculated lower and upper values between which each of the various O/E ratios would be likely to fall 95 times out of 100. The size of the gap between the minimum and maximum values depends on the number of cases being studied – the smaller the number, the wider the interval, and the greater the uncertainty in reaching a conclusion. An important aspect of this is that if the interval includes the value 1.0, then it is likely that any difference between the observed and expected figures is just due to the natural variability in the occurrence of the disease – what the researchers refer to as a result that could be due to chance.

Conclusions

The main conclusion of the study was that around the five Canadian nuclear facilities examined, there was no increase in the rate of childhood leukaemia comparable to that found near Sellafield in England.

The researchers noted that despite the inclusion of cases involving children up to age 14, the numbers were still quite small and this led to considerable uncertainty – the aforementioned intervals were generally quite large and always included 1.0. Consequently, in every comparison where the observed number of cases was different from the provincial average, either higher or lower, it was stated that the result could be due to chance. This applied as well to the finding that the childhood leukaemia rate around the Pickering power plant was slightly higher than the Ontario average both before and after it started operating.

Further research

As a response to a British study on the association between paternal radiation exposure and childhood leukaemia, the AECB is sponsoring similar research using the already identified childhood leukaemia data, combined with the valuable information on workers' radiation exposures contained in the National Dose Registry operated by Health and Welfare Canada. The results of this work, also being conducted by the Ontario Cancer Treatment and Research Foundation, should be published within a year.

Fellows class created

***Ed. Note:** At its 9 June 1991 meeting the CNS Council adopted the following policy statement for a new class of Fellows.*

Qualifications:

Fellows of the CNS/SNC are a senior class of professional members of the Society who have been judged to be of outstanding merit. Fellows must clearly be making a sustained and major contribution to the science and/or the professions which contribute to the advancement of nuclear technology in Canada. In general, members will not become eligible for consideration as Fellows until they have been members of the Society for at least five years. Maturity of judgement and breadth of experience will be requirements for selection as a Fellow in addition to technical capability, service to the Society and current membership.

Nature of the award:

Fellows will be presented with a certificate and be entitled to use the initials FCNS after their name. There will be no other changes in membership fees or privileges.

Certificates will be presented to those selected for this honour at the Annual Meeting.

Selection of nominees:

Each local Branch and each Technical Division of the Society should designate a Nomination Committee to review their professional members, on an annual basis, for consideration as potential Fellows. When one or more nomination is agreed on by this Nomination Committee, three members should prepare independent confidential nomination statements and forward these to the Chairperson of the Honours and Awards Committee. Nomination statements received by the Honours and Awards Committee from any other three Society members will be considered, but use of the Branch or Division route is preferred.

Selection of Fellows:

On receipt of three such statements, the Honours and Awards Committee must evaluate the nomination. This will be done on the basis of a points system developed by the Committee, so that there will be as little fluctuation in qualifications with time as possible. All recommendations for Fellowships from the Committee will be forwarded to Council for approval.

The points system will be based on the following:

1. Formal education or equivalent — 20 pts max.
2. Work history including publications, patents etc. — 30 pts max.
3. Breadth of experience and demonstrated maturity of judgement — 25 pts max.
4. Service to the CNS/SNC — 25 pts max.

Initially, the total points needed for promotion to Fellow will be 75. This number may only be reduced by decision of Council.

Number of Fellows:

No more than ten Fellowships will be awarded in any one year, and the maximum number of Fellows in the Society at any one time will be restricted to less than five per cent of the total Society membership at that time.

Branch News

Toronto Branch

Following is a summary of the Toronto Branch's successful 1990-1991 program.

Public Presentation Series:

The improved attendance record of this year's Public Presentation Program was due to several factors; the quality of the presentations themselves, the increase in Toronto Branch membership (i.e., student involvement at U of T), and the brochure which we generated at the beginning of the year to promote the program and to give advance notice of topics, speakers, and dates. Because of the favourable response to the brochure this year, the Toronto Branch will most likely continue to produce the brochure on an annual basis.

The 1990-1991 Public Presentation series included:

September 25, 1990
"Fusion Power in the Next Century: The ITER Project"
Mr. Robert Stasko, Canadian Fusion Fuels Technology Project
Attendance: 40 approx.

October 23, 1990
"The Future of Nuclear Power Safety"
Dr. Kenneth Hare, Professor Emeritus, University of Toronto
Attendance: 70-80

January 22, 1991
"The French Nuclear Power Program"
Dr. Philippe Lemoine, Electricité de France
Attendance: 80-90

February 26, 1991
"Hubble, Hubble, Toil and Trouble – The First Year of the Space Telescope"
Dr. John Caldwell, York University
Attendance: 40-50

March 26, 1991
"Changes in the Estimates of Risk Resulting from Exposures to Low Level Ionizing Radiation"
Dr. David Whillans, Ontario Hydro – Health and Safety
Attendance: 50-60

Copies of the AECB publication "Canada's Radiation Scandal?" were distributed.

May 14, 1991
"Final Disposal of Used Nuclear Fuel in Canada"
Mr. Egon French, AECL – Whiteshell Research
Attendance: 80 approx. (combined)

The meeting was held in two locations (AECL Sheridan Park and the University of Toronto) to allow a greater proportion of our members to attend. In the future, this practice will be continued whenever possible.

Formation of the Toronto Branch Student Chapter:

The formation, in 1990, of our first student chapter at the University of Toronto was largely due to the enthusiasm of Professor

Greg Evans, and the support from Professor Brian Cox at the U of T Centre for Nuclear Engineering. Turnout at CNS meetings has been enhanced by the presence of student groups. The CNS Toronto Branch has taken several initiatives in support of student involvement:

- A tour of the Ontario Hydro System Control Centre was organized for the U of T students and members of the Ontario Science Centre staff, and
- a student / industry beer and pizza party was held in March.

Nuclear Fuel Waste Management Hearings:

Ben Rouben and Shayne Smith made a verbal / written presentation, as CNS Toronto Branch members, to the Nuclear Fuel Waste Management Environmental Assessment Panel at the public scoping meetings held on October 22, 1990 in Toronto. The main features of the presentation were the identification of some of the technical issues relevant to the Environmental Impact Statement, and the importance of drafting guidelines for a public information program to accompany the public review process.

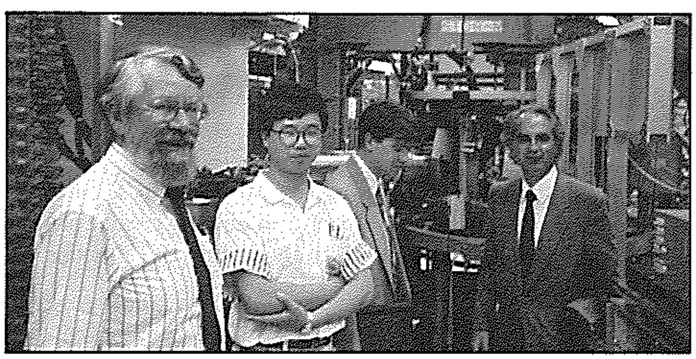
Collaboration with the Ontario Science Centre:

In March a meeting was held with several members of the Ontario Science Centre (OSC) staff to explore the possibilities of a collaborative program with the CNS. As a result of that meeting, there was a general agreement that involvement with the CNS would be of considerable benefit to the OSC and that the idea of a public tour would be pursued.

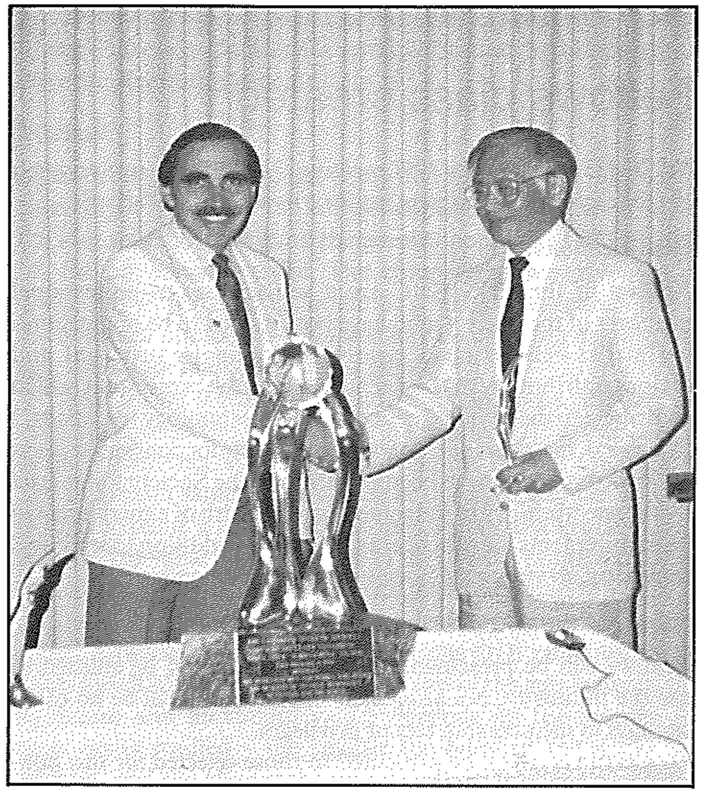
NSED Executive

Following is the new executive of the Nuclear Science and Engineering Division's executive for 1991-92.

V.S. (Krish) Krishnan *AECL CANDU* (Chairman)	Jean Koclas *Hydro Québec*
Joel Almon *Ontario Hydro*	Ron Robinson *Atlantic Nuclear Services Ltd.*
Nick Barkman *AECL CANDU*	Dave Wright *AECL CANDU*
Marv Gold *Ontario Hydro*	
Stu Iverson *AECL RC* - Whiteshell	Paul Thompson *NBEPC* (Past Chairman)



Members of the CNA / CNS Fusion Committee visit the fusion laboratory at the University of Saskatchewan during the CNS Annual Conference.



CNS outgoing president Hugues Bonin (L) congratulates Wing Tao on being one of the first recipients of the new CNS Innovative Achievement Award.

Annual Conference

Saskatoon was the locale for the 12th CNS Annual Conference, June 9 to 12. Again this year the CNS conference was held in conjunction with the annual conference of the Canadian Nuclear Association. Close to 400 registered for the joint meeting.

The CNS technical program saw 66 papers actually presented, down from the 97 accepted and 86 in the final program due to late withdrawals. Co-chairmen Alan Wighr and David Malcolm expressed pleasure at the quality of the papers submitted while being very disappointed with the last-minute cancellations. Abstracts were available at the conference and full Proceedings will be published in the fall.

Two CNS members won the major awards given by the CNA. Stan Hatcher, AECL president, was presented the Ian McRae award for his contributions to the Canadian nuclear industry and U of T professor Bob Jervis received the W.B. Lewis award for his scientific achievements.

The first presentations of the new CNS Innovative Achievement award went to Dr. Wing F. Tao and to Bill Morison, recently retired from Ontario Hydro.

A highlight of the conference was the rodeo / barbecue held on the Tuesday evening. The sudden rainstorm that came early in the (outdoor) rodeo program seemed only to create a stronger sense of conviviality.

On the official side the last meeting of the 1990-91 CNS Council was held on the Sunday afternoon, just prior to the opening of the conference, while the Annual General Meeting took place at 8:00 a.m. (!!!) Tuesday morning. (Needless to say, only the most dedicated attended.)

Annual Meeting

As usual the Annual General Meeting was a relatively short affair (although still longer than that of the CNA).

The report of the out-going president, Hugues Bonin, is presented elsewhere in this issue.

Treasurer Keith Bradley reported on a financially successful year, with an excess of income over expenses of $81,077, due largely to three successful specialized conferences. Copies of the audited statements are included in this issue.

Two major "topical" conferences were held in 1990: a Steam Generator and Heat Exchanger conference, chaired by Jim Brown, in the spring; and the Second International Conference on Containment Design and Operation, chaired by Paul Burroughs, in the fall. They and the Simulation Symposium coordinated by Bill Midvidy were financially as well as organizationally successful. The 11th Annual CNS Conference held in Toronto, which was co-chaired by Nabila Yousef and Ben Rouben, drew a record attendance and contributed to the financial surplus.

Program Chairman Bill Midvidy noted that a CNS Conference Planning Manual had been prepared and is available through the CNS office.

Branch activity varied considerably last year with some, like Toronto, having well-attended programs, while others faced considerable difficulties.

On the international front Ken Talbot reported on the signing of cooperation agreements with nuclear societies in Australia, Romania, and the USSR, and on-going negotiations with the European and Mexican Nuclear Societies. The cooperation agreement with the American Nuclear Society was strengthened and renewed.

Membership survey

Last spring Membership Chairman Jerry Cuttler prepared a questionnaire which was sent to all members. Although the response was just over 10% it is felt that the results (compiled by Jerry's wife Sandra) provide a valuable insight into the views and concerns of members.

On a few questions there was an overwhelming positive response:

- adequacy of communication
- adequacy of conferences / symposia / courses
- CNS involvement in public participation
- CNS responding to anti-nuclear statements

Others, such as participation in branch activities and desired articles in the CNS *Bulletin* drew mixed responses.

About 60% of the respondents chose "information on the Canadian nuclear industry" as the primary benefit of CNS membership. The remainder chose a variety of reasons.

Copies of the survey report are available from Jerry Cuttler.

News of Members

Dan Meneley, professor of Nuclear Engineering at the University of New Brunswick and formerly head of nuclear safety at Ontario Hydro, has been appointed to succeed **Gordon Brooks** as Vice-President and Chief Engineer of AECL CANDU. Gordon retires in September after a lifetime career with AECL.

Roger Humphries has been confirmed as Director General of the division of nuclear safety of the Department of National Defence. Roger, who is on exchange from AECL CANDU, had served for several months in an acting capacity.

Ken Talbot, a one-time president of the CNS, has been appointed as Manager of Ontario Hydro's Bruce 'A' Nuclear Generating Station. He was formerly Program Director, Corporate Planning.

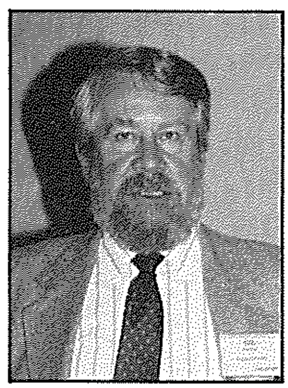
Ernie Siddall, a retired AECL engineer, has been awarded an honourary degree from the University of Waterloo for his extensive work on risk.

New N.B. Branch Executive

Chairman	H.E. Storey
Vice Chairman	D.B. Reeves
Secretary-Treasurer	R. Quan
Members of Executive	D.S. Cook
Member of Executive	S.A. Hasnain
Member of Executive	M.C. MacLean
Past Chairman	R.G. Steed

All are on the staff of, or on attachment to, Point Lepreau Generating Station.

New President



Dr. Gilbert Phillips

Dr. Gilbert Phillips has been elected president of the Canadian Nuclear Society for the 1991-92 year. He took office following the Annual General Meeting, June 11.

Gil did his undergraduate studies at the University of Manitoba and followed this with graduate work at the University of British Columbia where he obtained his Ph.D. in 1957.

He has been with Atomic Energy of Canada Limited since then. After a number of years in reactor physics and nuclear engineering, mainly on the application of digital computers to reactor design he was attached for 14 months to the UKAEA Winfrith Laboratory in 1970-71. Later he became involved in energy and economic analyses before joining the Fusion Canada office in 1986 where he is Manager, Fusion Fuels.

Gil has been active in the CNS since the formation of the society and has served in a number of positions on the CNS Council.

CNS Executive - 1991-92
Front Row (L-R): *Shayne Smith, Hugues Bonin (Past President), Gil Phillips (President), Bill Midvidy, Paul Fehrenbach.*
Back Row (L-R): *Alan Wight, Ken Talbot, Eva Rosinger, Dennis Bredahl, Kathy Krawczewski (CNA), Jerry Cuttler, Ben Rouben.*
Missing: *Keith Bradley, Dan Meraw.*

New Council

As there were no additional nominations, the 1991/92 Council for the Canadian Nuclear Society, as proposed by the nominating committee, was acclaimed at the Annual General Meeting held June 11 during the 12th Annual Conference in Saskatoon.

Following is the 1991/92 CNS Council.

CNS Executive

Past President	Dr. H.W. Bonin
President	Dr. G.J. Phillips
First Vice-President	Dr. W.I. Midvidy
Second Vice-President	Dr. P.J. Fehrenbach
Secretary	Dr. B. Rouben
Treasurer	Dr. K.J. Bradley
Members of Council	
Membership	Mr. J.M. Cuttler
Communications	Dr. D. Meraw
Public Affairs	Mr. S. Smith
International Liaison	Mr. K.H. Talbot
Member at Large	Dr. M. Shoukri
Member at Large	Dr. V. Langman
Member at Large	Mr. D. Bredahl
Member at Large	Mr. J. Sobolewski
Member at Large	Dr. D. Rozon

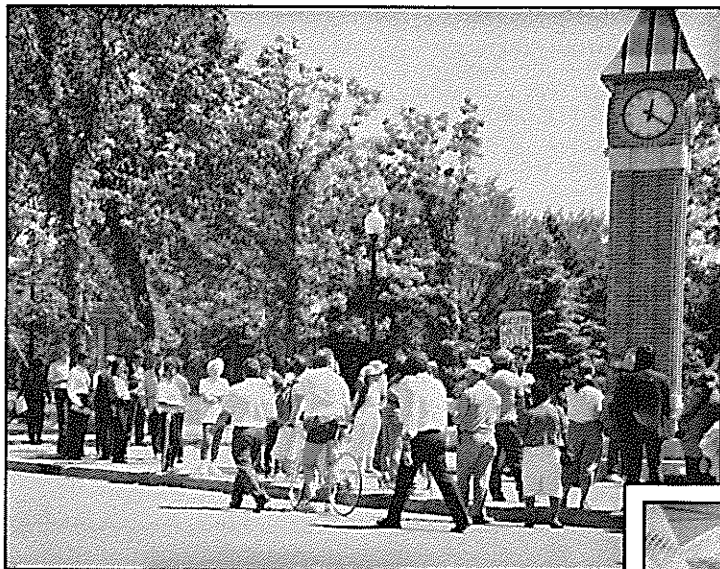
ROP Training Course

In conjunction with NB Power and Hydro Quebec, the Nuclear Science and Engineering Division of the CNS recently held a two-day course on regional overpower protection at Point Lepreau GS. The course was held on July 15 and 16, and was organized by Keith Scott, of Atlantic Nuclear Services (ANSL). Over thirty people attended.

Speakers included Chris Bailey and Frank Laratta of AECL CANDU, who are responsible for the re-design of the system, discussing the design and analysis; Ron Robinson and Jack Walsworth of ANSL, who are responsible for the ROSE code, used for the trip setpoint evaluation and operational support analysis, discussing operational aspects in support of design and analysis; and Fraser Smith and K.C. Playfoot of Imaging and Sensing Technology (Canada) Inc. (IST), who manufacture self-powered in-core detectors for the nuclear industry worldwide.

A similar course will be given at Gentilly-2, in French, in the early fall, arrangements being made by Andre Baudouin.

Scenes from the 1991 Conference



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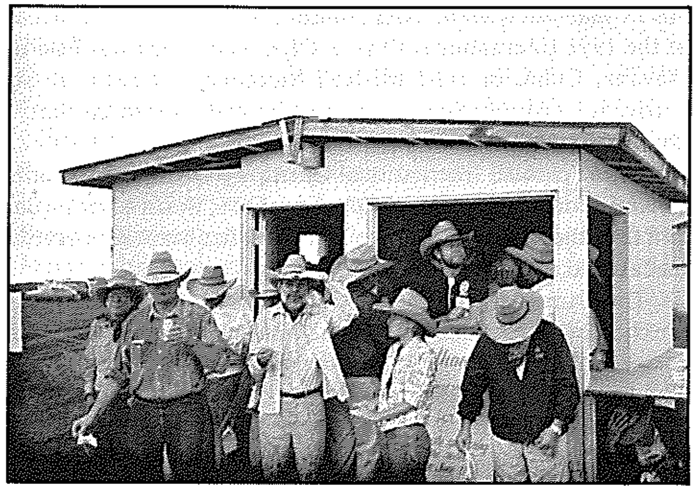

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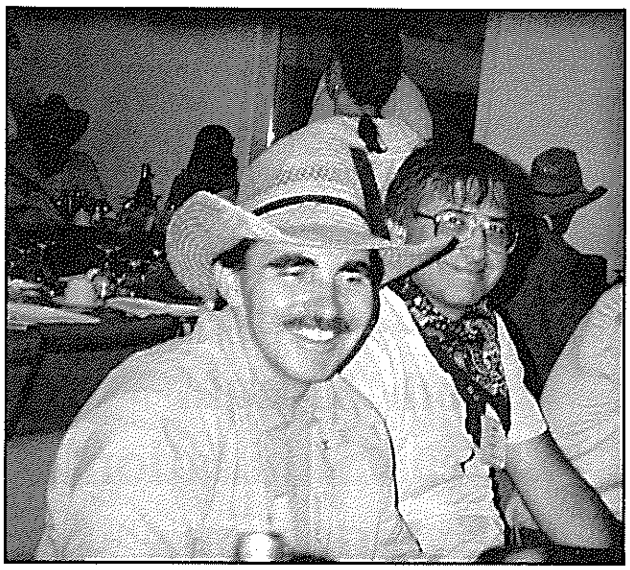

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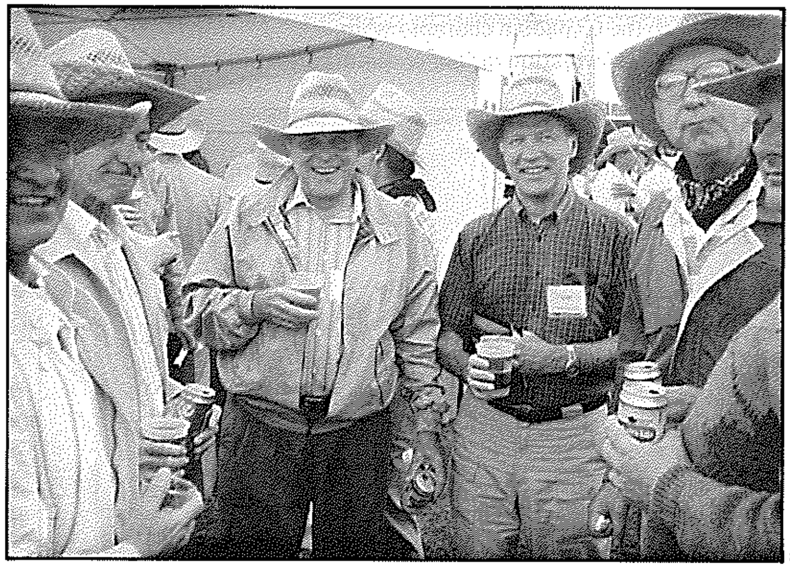

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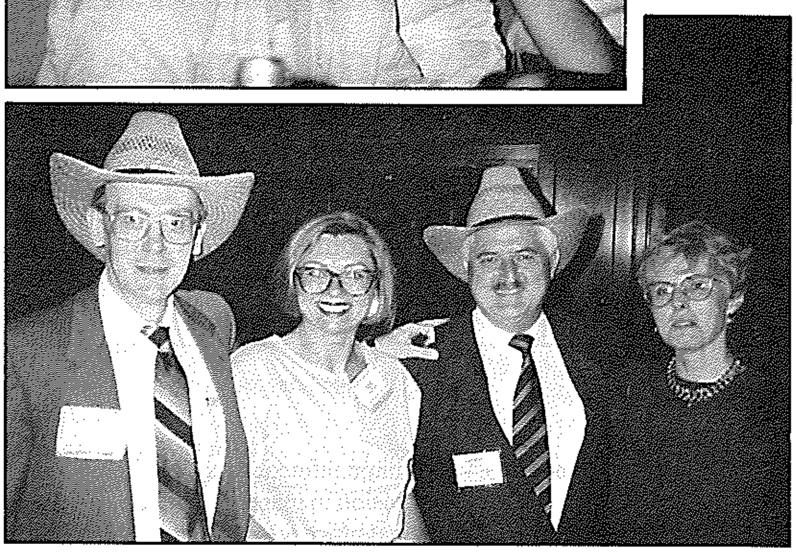

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1. *The small anti-nuclear demonstration outside the conference hotel.*
2. *Hugues Bonin and Ben Rouben at the barbecue.*
3. *Co-chairman Alan Wight and David Malcolm with staff members Eva Curlanis-Bart and Rita Mirworld.*
4. *When the rains came, at the rodeo/barbecue.*
5. *Ralph Green, Terry Rogers and others (before the rain) at the barbecue/rodeo.*
6. *At the hospitality suite.*

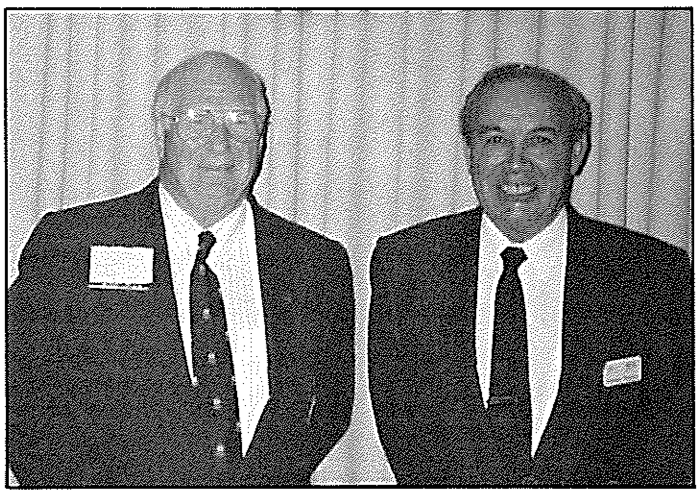
Canadian student wins physics prize

An 18-year-old student from Duncan, B.C., won a Gold Medal at the 1991 International Physics Olympiad which was held in Havana, Cuba, in July. Michael Montour, a student at St. Michaels University School, also tied for first place in the thirty-country competition.

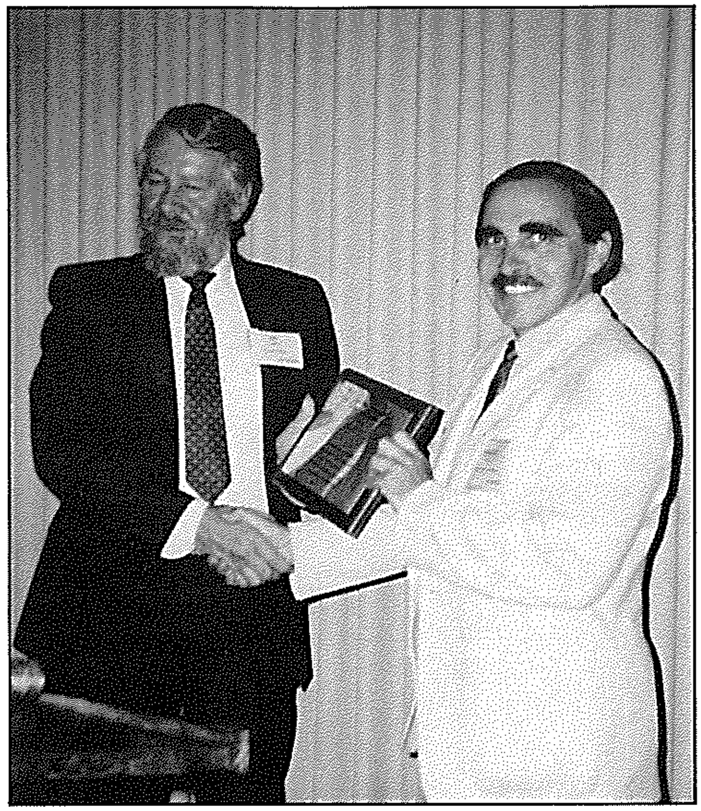
At the parallel International Chemistry Olympiad in Ladz, Poland, Eric Rubin from Beaconsfield, Que., won a silver medal and the other three members of the Canadian team won bronze medals and a certificate of merit.

The Canadian teams, of five members for physics and four for chemistry, were chosen from 38 finalists who took part in a national championship held at Royal Military College in May. The Canadian participation in the international competitions is organized by the Canadian Chemistry and Physics Olympiad, a non-profit group based in Toronto. The CNA and CNS have had some involvement and CNS past-president Hugues Bonin assisted with the Canadian championship.

For more information on the program call 416-484-6533.



Bob Jervis and Stan Hatcher, winners of the W.B. Lewis and Ian McRae Awards.



Incoming president Gil Phillips presents plaque to outgoing president Hugues Bonin.

LAST MINUTE!

16th Annual Nuclear Simulation Symposium

Saint John, New Brunswick
25-27 August 1991

For information, contact the CNS office
or Paul Thompson (506) 659-2220

AECB opens new office in Saskatoon

The AECB has opened a regional office in Saskatoon as a base for the manager and certain staff of the Uranium Facilities Division. The move was prompted by the increased workload related to the growing uranium mining sector in Saskatchewan.

Division manager Tom Viglasky will head the new eight-person office. The AECB's existing mine inspection office in Elliot Lake, as well as the Board's Ottawa-based personnel who are responsible for uranium refineries and fuel fabrication plants, also report to the division manager in Saskatoon.

The AECB's new regional office is located at:

101-22nd Street East
Saskatoon, Saskatchewan
S7K 0E1
Tel: (306) 975-6376
Fax: (306) 975-6387

Canadian Nuclear Society

Balance Sheet • January 1, 1991

	1991	1990
ASSETS		
CURRENT		
Cash	$ 41,435	$ 53,348
Accounts receivable	61,519	8,650
Prepaid expenses	1,000	—
Conference advance	—	6,500
Short term deposits	82,861	34,973
	186,815	103,471
EDUCATION FUND ASSETS HELD BY CANADIAN NUCLEAR ASSOCIATION (Note 2)	12,000	9,000
	$198,815	$112,471
LIABILITIES		
CURRENT		
Accounts payable	$ 13,849	$ 8,646
Payable to Canadian Nuclear Association (CNA)	9,823	—
Membership fees and contributions received in advance	8,072	20,831
	31,744	29,477
EQUITY		
OPERATING FUND SURPLUS	155,071	73,994
EDUCATION FUND SURPLUS	12,000	9,000
	167,071	82,994
	$198,815	$112,471

See accompanying notes to the financial statements.

Statement of Operating Fund • Year Ended January 31, 1991

	1991	1990
INCOME		
Membership fees	$ 31,565	$ 29,457
Publications	9,511	8,487
Interest	12,957	8,618
	54,033	46,562
SOCIETY PROJECTS		
Excess of income over expenditures		
Annual conference	33,218	4,256
Simulation symposium	—	5,000
89 CANDU fuel conference	(224)	5,844
CANDU chemistry seminar	4,335	—
Containment design and operation conference	28,261	—
Steam generator and heat exchanger conference	28,234	—
Simulation methods conference	21,417	—
Neutron radiography conference	2,653	—
	117,894	15,100
	171,927	61,662
EXPENDITURES		
Contribution to education fund (Note 2)	3,000	3,596
Office overhead	21,000	20,016
Office services	18,652	10,646
Canadian Nuclear Society bulletin	18,204	12,988
INC'93 feasibility study	10,000	—
Branch activities	2,691	5,943
Membership committee	4,709	859
Program committee and technical divisions	4,368	—
Stationery and printing	6,006	4,702
Council activities and promotion	500	2,745
Student conference	1,500	1,500
Officers' seminar	200	—
	90,850	62,995
EXCESS (DEFICIENCY) OF INCOME OVER EXPENDITURES	81,077	(1,333)
SURPLUS, beginning of year	73,994	81,717
1989 SURPLUS TRANSFERRED TO EDUCATION FUND	—	(6,390)
SURPLUS, end of year	$155,071	$ 73,994

See accompanying notes to the financial statements.

Statement of Education Fund • Year Ended January 31, 1991

	1991	1990
SURPLUS, beginning of year	$ 9,000	$ —
CONTRIBUTIONS		
Transfer from operating fund	3,000	3,596
Transfer of 1989 surplus from operating fund	—	6,390
Interest portion of transfers due to local branches	—	(986)
SURPLUS, end of year	$ 12,000	$ 9,000

See accompanying notes to the financial statements.

Notes to the Financial Statements • January 31, 1991

1. 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.

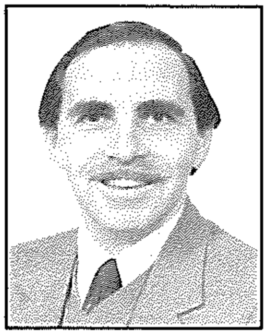
   (b) **Short Term Deposits**

   These investments are carried at cost plus accrued interest.

2. EDUCATION FUND

   Annual contributions amounting to $3,000 from the Society and $7,000 from the CNA are allocated from the income from the annual conference. The interest on these funds is available for educational purposes to the local branches of the Society. The principal remains the property of the CNA and the Society.

Rapport du fin d'annee



Hugues W. Bonin

En cette fin de mandat, il est approprié de récapituler les accomplissements et défis pour notre Société. Les objectifs généraux énoncés dans le Message du Président paru dans le numéro de l'Eté 1990 du *Bulletin* de la SNC ont été rencontrés, grâce aux efforts concertés des membres du Conseil de la Société Nucléaire Canadienne, de ses Officiers et de tous ceux qui ont collaboré aux divers comités ou oeuvré à la tenue des colloques. Tel que mentionné il y a près d'un an, la stratégie de répartir aussi uniformément que possible les diverses tâches parmi un grand nombre de personnes a effectivement très bien fonctionné : la réussite collective est vraiment impressionante !

Le premier des objectifs était d'augmenter le nombre de nos membres. M. Jerry Cuttler nous rapporte une augmentation des membres actifs de 528 à 586, avec encore une centaine de membres dont la cotisation est en souffrance. En ce contexte d'incertitude quant à une reprise prochaine de l'industrie nucléaire, due en grande partie au moratoire sur l'expansion du nucléaire en Ontario, cette augmentation est vraiment une performance remarquable.

Le second des buts fixés était la tenue d'au moins deux conférences majeures par année. La période 90-91 a été témoin de trois conférences thématiques, en plus de la conférence annuelle de la SNC et du colloque étudiant ANC/SNC. La SNC a aussi co-commandité 3 conférences organisées par d'autre sociétés nucléaires. Le programme de conférences de la SNC annonce pour bientôt quatre colloques majeurs avec implication de la SNC (Classe "A" et "B"), et cinq colloques de classe "C" (co-commandites). De plus, il est fort agréable de vous rapporter que toutes les conférences organisés par la SNC au cours des douze derniers mois ont été des succès complets tant du point de vue du nombre de congressistes et de la participation étrangère que de celui du nombre et de la qualité des communications, tout en étant des réussites financières. Le mérite en revient certes aux organisateurs de ces colloques.

La SNC est à planifier plusieurs autres conférences qui seront annoncés bientôt. Ce programme très actif a été rendu possible par les efforts soutenus du Dr Bill Midvidy et de son Comité du Programme, et par les Présidents des Divisions Techniques et leurs comités : Messieurs Paul Thompson, Ed Price, Al Lane et Keith Nuttall.

Parmi les conférences majeures figurant au programme se trouve INC'93, une super conférence qui vise à rassembler plus d'un millier de participants des quatre coins du monde à Toronto, en octobre 1993. En décembre dernier, l'Association Nucléaire Canadienne et la SNC ont voté de faire le grand plongeon et de commettre d'importantes sommes d'argent à la préparation de cet événement majeur. Plusieurs représentants des deux Sociétés, dont le Dr Stan Hatcher, le Dr George Pon et M. Ken Talbot, ont effectué plusieurs exposés sur ce projet à des rencontres internationales et ont réussi à obtenir le support de nombreuses sociétés et agences nucléaires de l'étranger.

La plupart des Sections Locales de la SNC ont présenté à leurs membres des programmes fort actifs et fort variés. La participation aux activités était souvent impressionante et encourageante. Le Dr Gil Phillips a pu visiter plusieurs Sections et les aider le cas échéant. Deux des Sections ont préparé des projets pour utiliser les Fonds pour l'Éducation, projets acceptés par le Conseil. La Section du Québec s'est réactivée et un bon auditoire a écouté le Dr Phillips présenter les grandes lignes du Programme Fusion Canada en février dernier. Le Président de cette section, M. Pierre Wolfshagen, y a été fort encouragé de présenter d'autres activités.

Un autre des buts fut atteint lorsque le Dr Keith Nuttall a accepté la Présidence de la Division Technique de la Gestion des Déchets et des Affaires Environnementales. L'automne de 1990 a vu la création d'un premier comité conjoint SNC-ANC. résultant de la fusion du Comité des Communications de la SNC et du Comité de l'Éducation et des Ressources Humaines de l'ANC. Trois des membres du Conseil de la SNC, Messieurs Dan Meraw, Terry Jamieson et Shayne Smith, ont servi activement sur ce comité qui a tenu quatre réunions depuis sa création. Le project majeur de ce comité était la production d'une brochure sur les carrières dans l'industrie nucléaire, à l'intention des étudiants du secondaire et du collégial qui s'apprêtent à prendre des décisions sur leur orientation. On a rapporté récemment que la brochure serait disponible sous peu. Un second comité conjoint a vu le jour peu après et fut appelé Comité de la Fusion ANC/SNC. M. Shayne Smith a participé activement à ce Comité.

Sur la scène internationale, les relations avec les autres sociétés nucléaires ont pris de l'expansion. La SNC a signé des documents d'entente avec les deux sociétés nucléaires suivantes : la Société Nucléaire de l'Union des Républiques Socialistes Soviétiques, et l'Associata Romana Energia Nucleara. On a tenu des discussions sur la signature de documents de coopération semblables avec les sociétés nucléaires suivantes : l'European Nuclear Society, l'Australian Nuclear Association et la Sociedad Nuclear Mexicana. Les documents officiels devraient être paraffés au cours des prochaines semaines. De plus, les contacts se sont maintenus avec les sociétés qui ont déjà conclu des ententes avec la SNC. Notamment, des représentants de l'American Nuclear Society et de la Société Nucléaire Chinoise ont visité récemment les bureaux de la SNC.

La SNC est sur le point de lancer avec la Société Française d'Énergie Nucléaire un programme d'échange d'étudiants ou de jeunes professionnels, par lequel chacune des sociétés pourra envoyer des étudiants passer de courts stages dans les centres nucléaires (ou universités) en France et au Canada.

Un événement important a été la participation active de la SNC dans les discussions qui ont mené à la formation du Conseil Internationale des Sociétés Nucléaires. Les termes de l'accord final ont été basés sur ce que l'on a appelé le "Compris Canadien" proposé par notre ex-président Ken Talbot qui, de concert avec le Dr Ben Rouben, ont mené à bien les affaires internationales avec brio.

M. Tony Natalizio, l'un des membres du Conseil, a été chargé des liaisons avec les autres sociétés savantes Canadiennes. Grâce à ses efforts, la SNC a participé à la "Semaine du Génie" organisée par plusieurs sociétés de génie en mars dernier, pour les écoliers du secondaire. Il a aussi établi des contacts avec la Société Canadienne pour le Génie Chimique, afin que chacune des sociétés soit tenue au courant des activités de l'autre et, on l'espère, que l'on puisse tenir des colloques conjoints d'intérêt mutuel pour le bénéfice de tous les membres.

Le *Bulletin* de la SNC a atteint sa vitesse de croisière de quatre numéros par an, et son Rédacteur en Chef, M. Fred Boyd, voit à assurer une qualité en amélioration soutenue. En passant, il compte toujours sur les membres de la SNC pour lui fournir des articles de toutes sortes. Notre ex-président Joe Howieson a rassemblé et présidé le Comité des Distinctions et Récompenses qui fut tenu fort occupé à établir les modalités d'attribution du nouveau Prix de l'Innovation et à juger des candidatures qui lui ont été soumises. Le Comité a de plus collaboré avec un spécialiste au design de la sculpture-trophée. Enfin, on a augmenté les tâches du Comité en lui demandant de rédiger les termes de référence et les modalités d'attribution d'une nouvelle distinction que la SNC veut accorder à ses membres exemplaires au cours des années qui viennent: le "Fellowship" de la Société Nucléaire Canadienne.

Le portfolio des Affaires publiques a vu la continuation de ses activités dans le programme "L'Éducation des Éducateurs", sous la gouverne de M. Jim Brown. Le Président de la SNC a de plus échangé une correspondance avec le Premier Ministre de l'Ontario, l'Honorable Bob Rae, sur nos inquiétudes sur la politique du NPD en matière d'énergie nucléaire. Des lettres furent aussi envoyées aux ministres de l'Énergie d'Ottawa et de trois provinces pour attirer leur attention sur une déficience de représentation de ces ministères à une prochaine conférence des Nations-Unies sur l'Environnement.

La SNC a soumis plusieurs exposés via ses Sections Locales aux auditions du Bureau Federal d'Evaluation et de Revue en Matières d'Environnement. Enfin, la SNC a été invitée à contribuer au Forum des Citoyens sur l'Avenir du Canada, mieux connu comme Commission Spicer. Un exposé de Point de Vue fut alors préparé par le Conseil avec grand soin et soumis à M. Keith Spicer.

On a aussi pris soin de plusieurs affaires de nature domestique au cours de l'année. Une entente de trois ans a été conclue avec l'ANC sur un partage plus équitable des coûts de fonctionnement du bureau-chef. Le Comité du Programme est à mettre la touche finale à une guide sur l'organisation des conférences de la SNC. La Constitution de la SNC a vu son texte final adopté par le Conseil. On a effectué les démarches nécessaires pour que les cartes de crédit puissent être utilisées pour payer les cotisations ou les frais d'inscription aux conférences. Les employés du bureau-chef se préparent au grand déménagement vers de nouveaux locaux au 144 rue Front ouest à Toronto. Un Comité ad-hoc formé du Dr Bill Midvidy et de M. Ken Talbot a été établi pour dresser la liste des candidats pour le Conseil de 91-92. Je laisse ici au nouveau Président le Dr Gil Phillips, le plaisir d'annoncer la composition du nouveau Conseil. Trois des membres du présent Conseil méritent certes nos remerciements pour leur contribution que l'on est porté à prendre pour acquise: M. Dennis Bredahl, notre Secrétaire, le Dr Paul Fehrenbach, qui a contribué au Comité des Distinctions et Récompenses, et le Dr Keith Bradley, notre Trésorier, qui a gardé nos finances en bon ordre, avec diligence et efficacité. Le nouveau budget voté il y a quelques mois, prévoit plus de services pour nos membres, mais au prix d'un modeste déficit plus que compensé par les recettes excédentaires de l'année précédente.

Les membres du Conseil et les Officiers de la SNC ont répondu avec empressement à mon appel pour leur support et ils méritent certes mes remerciements. Notre administratrice, Mme Kathy Krawczewski, et les employés du bureau-chef méritent aussi nos remerciements pour leur dévouement et leur collaboration enthousiaste, toujours dans la bonne humeur. Ce terme comme Président de la SNC a été pour moi une expérience des plus plaisantes, et c'est avec entrain que je me prépare à servir notre Société comme président sortant. Je pense qu'il est de mise ici de reconnaître le support de nos employeurs qui ont rendu possible les voyages nécessaires à nos nombreuses réunions. Personnellement, je voudrais remercier les autorités du Royal Military College of Canada pour l'aide constante qu'elles m'ont accordée.

J'aimerais souhaiter à mon successeur, le Dr Gil Phillips, une excellente et agréable année comme Président de la SNC et lui assurer tout mon support.

Hugues W. Bonin
Président sortant

Year End Report

As the 1990-91 Business Year for the CNS draws to a close, it is time to consider the accomplishments and challenges for our Society. The general objectives outlined in the President's Message in the Summer 1990 CNS *Bulletin* have been met, thanks to a concerted effort by the Council members, the CNS Officers and all those who participated on the various committees and conference organizing groups. As it was mentioned about a year ago, the trick of spreading as uniformly as possible the various tasks among a large number of persons has worked out: the amount of collective achievement is impressive!

The first objective was to increase the membership. Mr. Jerry Cuttler reports an increase of paid-up members from 528 to 586, with still over a hundred persons listed as unpaid. In the uncertain context of nuclear power in Canada, due in good part to the moratorium on further nuclear expansion in Ontario, this is indeed a remarkable performance.

The second objective was to sponsor at least two major conferences a year. The 1990-91 period saw three topical conferences, in addition to the CNA/CNS Annual Conference and the Student Conference. Also, the CNS co-sponsored three conferences organized by other nuclear societies. A glance at the rolling program reveals that four major conferences are listed as "Class A and B" (major involvement), along with five "Class C" (in name only) co-sponsored conferences. It is a real pleasure to report here that all of the 90/91 CNS conferences have been very successful in the number of attendees, the number and quality of the papers presented, the importance of the international representation and from a financial viewpoint. Merit goes to the dedicated steering committees of these conferences.

More conferences are now in early planning stages and should soon appear in the rolling calendar. This busy CNS program has been made possible by the sustained dedication of Dr. Bill Midvidy and his Program Committee, and by the Chairmen of the CNS Technical Divisions and their committees: Paul Thompson, Ed Price, Al Lane and Keith Nuttall.

Among the major conferences on the program is the INC '93 super conference, intended to gather in Toronto well over a thousand participants from all over the world. In December 1990, both the CNS and the CNA voted to take the big plunge and commit large sums of seed money into this venture. Several representatives from both Societies, in particular Dr. Stan Hatcher, Dr. George Pon and Mr. Ken Talbot, have done several presentations on this proposal at international meetings and have gained the support of several nuclear societies and agencies abroad.

Most of the CNS Branches have held lively programs of activities, and the attendance at their functions has been often impressive and encouraging. Dr. Gil Phillips has visited several of them in the past year and provided help when needed. Two of the Branches had their projects accepted by the Council to use their allocated part of the Education Funds. The Quebec Branch has held a first activity in years when a good crowd attended a seminar on Fusion in Canada given by Dr. Phillips last February. The Chairman of this Branch, Mr. Pierre Wolfshagen, felt much encouraged to organize more activities.

Another of the goals was reached when Dr. Keith Nuttall agreed to chair the Waste Management and Environmental Affairs Division of the CNS. The Fall of 1990 saw the creation of a first CNA/CNS joint standing committee as a result of the merger of the CNS Communications Committee and the CNA Education and Human Resources Committee. Three CNS Council members, Mr. Terry Jamieson, Dr. Dan Meraw, and Mr. Shayne Smith, served actively on this committee which met four times since its creation. The committee's main task for 90/91 was the production of a booklet on careers in the nuclear industry intended for high school students. It was reported recently that the booklet will soon be available from the CNA/CNS. Another joint CNA/CNS committee was created shortly after and named the CNA/CNS Fusion Committee, to look after nuclear fusion matters and possibly organize conferences on the many aspects of controlled nuclear fusion. Mr. Shayne Smith is the one responsible for this achievement.

On the international scene, the relations with other nuclear societies were expanded. Documents of agreement of cooperation were formally signed between the CNS and two nuclear societies: The Union of Socialist Soviet Republics Nuclear Society, and the Associata Romana Energia Nucleara. Discussions have been held on similar documents of cooperation between the CNS and the following nuclear societies: European Nuclear Society, Australian Nuclear Association and Sociedad Nuclear Mexicana. These documents should be signed formally in the coming weeks. In addition, contacts were maintained with those Societies having already signed a cooperation document with our Society: in particular, representatives from the American Nuclear Society, and the Chinese Nuclear Society, have recently visited the CNS/CNA head office.

With La Société Française d'Énergie Nucléaire, the CNS is about to initiate a program of exchange by which each of the Societies will send students or professionals for short stays at nuclear centres (or universities) in France and Canada.

An important event on the international front has been the active participation of the CNS in the process leading to the formation of the International Nuclear Societies' Council. The terms of the agreement were based on what has been called "The Canadian Compromise" set forth by Past President Ken Talbot who, with Dr. Ben Rouben, have handled the International Affairs portfolio in a superb way.

One of the Council members, Mr. Tony Natalizio, was charged with the task of liaising with other Canadian learned societies. Thanks to his efforts, the CNS participated in "Engineering Week", held by several engineering societies in March '91 for high school students. Contacts have also been made with the Canadian Society for Chemical Engineering in order to inform each Society of their program of activities and, hopefully, co-sponsor conferences of mutual interest for the benefit of our members.

The CNS *Bulletin* has reached its cruising speed of four issues per year and continues to be improved under the apt govern of its editor, Mr. Fred Boyd (who, by the way, still needs as many contributions as possible from the CNS members).

CNS Past President Joe Howieson gathered and chaired the Honours and Awards Committee which spent a very busy year working on the rules of the new Innovative Achievement Award and selected its first recipient. In addition, the committee worked with professionals and designed the sculpture serving as a trophy for this Award. The tasks of the committee were augmented when its members were asked to formulate the terms of reference and rules of a new distinction that the CNS plans to offer to its most outstanding members in the coming year: the Fellowship of the Canadian Nuclear Society.

The Public Affairs portfolio saw a continuation of its activities with the "Educating the Educators" program, led by Mr. Jim Brown. Correspondence was exchanged between the President of the CNS and Hon. Bob Rae on the concerns about the NDP views on nuclear power. Letters were sent recently to the Ministers of Energy of the Federal Government and of three provinces to draw their attention to the lack of representation from ministries of energy at an up-coming United Nations conference on the environment.

The CNS made representations through several of its Branches at hearings of the Federal Environmental Assessment and Review Office (FEARO), on nuclear fuel waste management. Finally, and not the least, the CNS was invited to contribute to the Citizens' Forum on the Future of Canada, better known as the Spicer Commission. A brief was carefully prepared and submitted to Mr. Keith Spicer.

Housekeeping items were also looked after during the year. A three-year agreement was reached with the CNA on head office cost sharing. The Program Committee is finalizing (at this writing) a guide for CNS Conference organizers. The CNS Constitution, Policies and By-Laws were adopted in their final form last summer. The CNS can now accept payments (such as membership fees) with major credit cards. The headquarters staff is all prepared for the big move to 144 Front St. West, Toronto in late July. An ad-hoc committee, made up of Dr. Bill Midvidy and Mr. Ken Talbot, was appointed to establish the list of candidates for the 91-92 CNS Council. Three of the present Council members indeed deserve our thanks for their dedicated support which is often taken for granted: Mr. Dennis Bredahl, the CNS Secretary; Dr. Paul Fehrenbach, member-at-large, who contributed in a major way to the Honours and Awards Committee; and Dr. Keith Bradley, our Treasurer, who kept the finances well in hand efficiently. The budget voted a few months ago foresees expanded services to the members, but implying a modest deficit more than compensated for by the surplus of Year 89/90.

The Council members and the Officers have responded admirably to my request for support and they truly deserve my gratitude for their enthusiastic collaboration. Our administrator, Mrs. Kathy Krawczewski and her staff, duly deserve our thanks for their dedicated support and their cooperation always done with smiles. Serving the CNS has been a very pleasant experience for me and I look forward to continue serving our Society as Immediate Past President. I think that the support of our employers deserves recognition from the CNS Council, as the attendance to the numerous meetings of the Council and the Committees has been made possible by our employers. This token of support is, in my personal case, most remarkable and the authorities of Royal Military College of Canada should be thanked for supporting my Presidency so well.

I wish my successor, Dr. Gil Phillips, an excellent and pleasant year as new President of the Canadian Nuclear Society. I would like here to assure him of all of my support.

Hugues W. Bonin
Outgoing President

AECB modifies licence fees

The Atomic Energy Control Board has issued a Consultative Document (C-126) on "Proposed Amendments to the AECB Cost Recovery Fees Regulations" and the proposed 1992 regulations.

Fees will be increased significantly on the basis of the AECB's reported 22 per cent increase in expenditures. The structure of the fee system is also to be changed, with some, such as the decommissioning fee for accelerators being eliminated, and others, such as that for a "removal" licence for uranium mines, being changed from a one-time to an annual fee.

Fees range from $250 for an application for a radiography operator examination to $39,551,000 for a construction licence for a four-unit nuclear power station.

Comments on the proposed amendments will be accepted until September 8, 1991 for incorporation into the required "Regulatory Impact Assessment Statement".

Copies of the Consultative Document and proposed regulations are available from the Cost Recovery Unit of the AECB, P.O. Box 1046, Station B, Ottawa, K1P 5S9; telephone 613-943-8765.

FUSION SEMINAR

"CANADIAN PARTICIPATION IN WORLD FUSION: OPPORTUNITIES AND CHALLENGES"

OCTOBER 24th, 1991
OTTAWA

A seminar organized by the Fusion Sub-Committee of the Canadian Nuclear Association and the Canadian Nuclear Society in co-operation with the Canadian Fusion Fuels Technology Project, le Centre canadien de fusion magnétique and the National Fusion Office.

OBJECTIVE

The objectives of this seminar are to provide:

- an update on world fusion developments;
- an update on Canadian fusion research and development activities and Canadian participation in world fusion programs;
- a forum for interaction amongst the fusion projects, industry, universities, research laboratories and government agencies and officials;
- an opportunity for high technology companies not currently involved in fusion, to assess whether their products and services have applications in fusion;
- a forum for discussion on possible synergies between fusion research and development and other high technology sectors of the economy.

WHO SHOULD ATTEND?

The meeting will be of value to organizations currently involved in fusion energy, private companies and organizations that see the fusion program as a potential market for their products and services, and organizations that could benefit from potential spin-offs from fusion energy research and development. The meeting will be of interest to individuals involved in the management of high technology.

REGISTRATION

The registration fee of $125.00 payable to the Canadian Nuclear Association, includes luncheon and a reception the evening of October 23rd.

Nuclear Regulation in Canada and the U.S.A.

Perceptions of a User

John Graham

Ed. Note: *Last year John Graham, then Director of Licensing for AECL Research, gave this view of the Canadian and American nuclear regulatory systems to a meeting in Boston. Although John has moved back to the U.S.A. and some of the details are slightly out of date, his comments remain interesting and informative.*

Two hundred years ago, Charles Colton noted that *"Of the professions, it may be said that soldiers are becoming too popular, parsons too lazy, physicians too mercenary, and lawyers too powerful."*

A report by F.H. Ahearne, published in *Progress in Nuclear Energy* about 18 months ago, very succinctly and accurately contrasted the operations of the U.S.NRC and the Canadian Atomic Energy Control Board, the AECB. The bottom line was that the U.S.NRC approach is *legalistic and adversarial*, based on extensively documented regulations,[1] while the AECB approach is *collegial*, based on a few pages of regulations.[2]

Thus, Colton's comment about lawyers is pretty relevant today, since the Canadian regulatory authority has only three lawyers on its staff (about one per six reactors) while the U.S.NRC had 96 lawyers at the last count (about one per reactor). That sort of overload of legal talent in the U.S. is bound to affect the way things are done.

The Canadian Nuclear Scene

There are currently 18 CANDU (*CANada Deuterium Uranium*) power reactors operating in Canada (eight at each of two sites in Ontario – Pickering and Bruce, one at Point Lepreau in New Brunswick and one at Gentilly in Quebec). The total capacity is 12 Gigawatts, representing 17% of Canada's total electricity supply. Four more reactors are close to being finished at Darlington, Ontario. Most of the nuclear capacity is in the east of the country, so that 47% of Ontario's electricity, and 34% of New Brunswick's electricity, is nuclear, whereas British Columbia, for example, gets 95% of its power from hydroelectric plants and most of the rest from natural gas (Table 1).

Atomic Energy of Canada Limited (AECL) is a Canadian Crown Corporation established in 1952, answerable to the Minister of Energy, Mines and Resources and charged with the development of peaceful uses of nuclear technology. It has two nuclear research establishments: Chalk River Nuclear Laboratories on the Ottawa River 200 km upstream of Ottawa in Ontario; and Whiteshell Nuclear Research Establishment, 110 km east of Winnipeg in Manitoba. *Chalk River*, established in 1945 as part of the weapons program, has some 2,200 personnel with a large number of facilities; research laboratories of all kinds, isotope production facilities, test loops for CANDU development work, accelerators and research reactor facilities which include the older NRX and NRU heavy water reactors. *Whiteshell*, established in 1962, is smaller, with about 1,000 personnel. It too has a number of research facilities including full size thermalhydraulic test loops, and the Slowpoke Demonstration Reactor (SDR). The older WR-1 organic-cooled research reactor has been decommissioned. Close to Whiteshell is the Underground Research Laboratory which is performing geoscientific research in granite at depths up to 400 metres in support of the design of a high-level waste repository.

AECL has other major establishments, one of which is in Mississauga, a suburb of Toronto. This division, CANDU Operations, does the advanced design work for new CANDU power plants. This Division also has a design office in Montreal, Quebec, which is engaged in the design and management of the MAPLE family of research reactors and away-from-reactor used fuel storage systems.

Power reactors are owned by three nuclear provincial utilities: Ontario Hydro, New Brunswick Power, and Hydro-Quebec, all of which are provincial Crown agencies – none are private companies. Ontario Hydro owns the bulk of nuclear investment in Canada, and is therefore a very large organization with a strong design and operational capability. There is some overlap in capabilities between Ontario Hydro and CANDU Operations in Mississauga. A recent ministerial study recommended efficiencies in this area by consolidation of the nuclear industry in Canada.

The Atomic Energy Control Board (AECB) is also a Federal Crown agency charged with the regulation of all nuclear applications within Canada, including CANDU power reactors and the nuclear research sites. It is an independent organization answerable to Parliament only once a year when funds are requested. They are not subject to Congressional oversight in the U.S. The AECB has a small staff compared to the U.S. NRC; it has a staff of 260 with very recent permission given to expand that number to 353 over the next three years, compared with the NRC's staff of 3,800. The U.S. reactor regulation activity is funded at an average of $3 million (or 15.6 person-years) per reactor, while the Canadian regulatory commitment is only $0.3 million (or 3.9 person-years) per reactor.

Both AECL sites, at Chalk River and Whiteshell, have overall site licenses issued by the AECB, and the sites have a responsible AECB Project Officer who regularly monitors operations, although he is not located at the site. However, a continuing safety review of on-site operations is made by an internal committee, the Nuclear Safety Advisory Committee (NSAC), composed of senior AECL staff. They approve all changes and operations which lie within the envelope of the site licences. AECB staff are observers on NSAC, so they are aware of all changes that are made.

Ed. Note: *The above arrangement is being changed.*

A U.S. approach to new systems

My safety and licensing experience, though initially from Britain, is almost all from the U.S.: first, on the ill-fated Clinch River Breeder Reactor in Tennessee, and, secondly, on the equally ill-fated Basalt Waste Isolation Project out in Hanford, Washington. Since both projects were effectively new technology, the regulations were incomplete. Ensuring that the systems were both safe and seen to be safe, was like swimming in the dark. There wasn't much to hold onto, it wasn't obvious which way one had to proceed, there certainly never was a secure harbour, and there were sharks in those waters.

"Ensuring the systems were safe and seen to be safe was like swimming in the dark."

In particular, in high level waste repository evaluation, a crucial question to be asked is *"If radionuclides are loose in the groundwater down below will they move and migrate through rock along groundwater paths?"* The EPA criterion was that groundwater should not reach the accessible environment, 10 kilometres away, in 10,000 years. (This criterion involved a boundary of approximately 5 kilometre radius in 100,000 years by the time NRC and DOE had worked on it.) The difficulty at Hanford is that the groundwater hardly moves at all – it was so difficult to detect movement at the 3,000 foot depth that data had to be corrected for the phase of the moon and there was great uncertainty as to the direction of motion, if it was moving at all. Yet, the regulations *required* an answer for the probability of a drop of water travelling 10 kilometres in 100,000 years. The answer *the groundwater doesn't move* wasn't good enough. Nor was the idea that the number is just not calculable, even though an ice age would have come and gone in that 100,000 years. Once a number, however spurious, was calculated, it became the basis for argument and ratchetting. Even the error band on this imaginary number became the source of discussion. Regulators and the Government conveniently forgot they were, by now, dealing with fantasy. In contrast, the Canadian regulations require that beyond 10,000 years only reasoned arguments that no sudden or dramatic increases can result in acute exposure.

The Canadian approach to new systems

My first task within Canada, in late 1968, was to review safety and licensing activities at Chalk River and Whiteshell nuclear research sites of AECL and to assess their effectiveness with the AECB. You can imagine how amazed I was to find that the licensee and licensor were used to working in a collegial or a collaborative fashion, determining, between themselves, the best way to regulate a facility safely. I found myself advocating criteria, guides, documentation, and records while everyone looked at me strangely. Since then I have come to understand that there is a great deal to be said for the collegial process.

How does the system work?

One of the new small reactors of AECL is a heating reactor, rated at 10MW. Its operational time constants are long ... hours and days rather than seconds and minutes. It uses light water to cool the small core by natural circulation in a tall narrow tank closed by a loose fitting cover, and through heat exchangers it is designed to provide hot water for a large hospital, university, or apartment block. Thus it is destined to be as numerous as large diesel boilers. The intention is to have a number of these units in a city, each manned locally by a heating engineer, and monitored centrally by an expert operations team. The local engineer would do no more than press a large red button should a red light shine. All other anticipated and unanticipated events would occur so slowly that the remote operators would have at least 48 hours to respond. The question is: Is this mode of operation licenseable?

It is *not* unlicensable, since no regulations prohibit remote monitoring and operation. Thus a presentation was made to the AECB staff detailing the qualifications and training of the local personnel, and those of the remote operator, and detailing what each would be expected to do, and in what time-scales: immediately, within an hour, within 48 hours, and periodically. The presentations all made very good sense. The project had also considered that the off-site operator might have the same problem as a *Maytag®* repairman, nothing much to do, so a human factors assessment was performed to ensure that his response was ensured.

"... there is a great deal to be said for the collegial process."

However, the response of the AECB staff was moderately negative to the idea of remote operation. A few unwritten requirements, or guidelines, came to light. In addition to being responsible for all operational changes to the reactor:

- an operator should be able to verify that operation is proceeding satisfactorily on a continuous basis, and verify that an acceptable trip has occurred (i.e., have the rods all gone in?)
- trips should be reset shortly after a shutdown (not 48 hours later)
- setbacks (shutdown by controller) should be sealed in and not be automatically cleared ... as in a kind of demand load-following operation
- the operator should be trained in accident management for events beyond the design basis
- more than one trained operator is assumed to be required to perform the necessary remedial actions in response to upset conditions.

Well, these views of an operator's responsibilities for a small reactor were news – clearly it is power reactor (CANDU) philosophy and the comments of the staff at the meeting constituted a first "listing" of operator requirements. Does this mean then that these requirements are sealed in stone? On the contrary – they are criteria by which the AECB staff presently looks at an operator's role. They are in U.S. terms – *Branch Positions.* It is now up to the proponent to show how all these needs can be fulfilled with the proposed mode of operation. It's a first bid in the negotiation ... and the negotiation is made easier for this new product since rules are not prescribed.

U.S. Design Safety Criteria for New Reactor Designs

In the early 70's, the Fast Flux Test Facility was in the final stages of design, and the Fast Reactor Demonstration Plant, which later became the Clinch River Breeder Reactor, had been initiated. Its design presented some interesting challenges especially because there were no established design safety criteria. The U.S.NRC rules specifically addressed light-water reactor designs. The sodium-cooled fast reactor is different in a number of very significant ways:

- core thermal time constants are much shorter than in the LWRs.
- the core is closely packed and structural movements have a significant reactivity effect, and
- dual shutdown systems are required.
- the primary system was at atmospheric pressure.
- fuel and coolant temperatures were much higher, and consequently
- stainless steel vessels and piping are thin and subject to plastic strains.
- an intermediate loop insulates the primary from heat exchanger failures.
- the coolant is sodium, so
- sodium fires and sodium-water interactions need to be addressed.

The design of thin flexible vessels and piping was the subject of an ASME Boiler and Pressure Vessel standard code case in the early seventies. The standardization of general design criteria however proved to be a much longer task. Guidelines were first developed by a joint working party within the American Nuclear Society standards program. These were later embodied in the Clinch River Breeder Reactor Project (CRBRP) design criteria, and then, with some changes relating to containment, in U.S. NRC fast reactor design criteria. A standard on the design criteria, ANS 54.1, was published finally in 1988, long after the demise of CRBRP. The formality of the standards process, while providing significant safeguards, is very long and arduous.

Small Reactor Design Safety Criteria in Canada

Few safety criteria exist for small reactors in Canada. Currently, guidelines are being set by iteration ... decisions are having to be made at a working level, and then these decisions become the unwritten "rules" for the next decision. For example, the AECB staff suggested that it would be appropriate to set a design basis tornado, at Chalk River, as that which occurred with a probability of 10^{-4} per annum. The data, however, predicted a windspeed of 125 km/hr (77 mph), which didn't seem high enough, so the AECB staff suggested a windspeed of 240 km/hr (150 mph). This selection may require establishing a design basis tornado as one which occurs with a probability of 10^{-5} per annum.

To develop criteria outside the exigencies of an actual project, in a similar manner to a U.S. standards committee, a working group has been established to work on a framework for small reactor safety criteria. This working group is composed of a licensing person from AECL, a regulator from AECB, a safety analyst from AECL, and a nuclear engineering representative from McMaster University. Together they have been working on overall risk guidelines, intending to develop, from the top down, useable safety design and operational criteria. Fortunately, the collegial Canadian manner of establishing adequate safety bases makes this sort of working arrangement acceptable. In the U.S. such collaboration would have to take place within the formality of an ANS standards committee.

Contact with the Regulatory Authorities

In the U.S.A. meetings with the U.S.NRC are open, preannounced, and highly formalized. All material appears in the public document room and even more is available under the Freedom of Information Act. Proponents and regulators work in open goldfish bowls. Suspicion abounds, and the issue of conflict of interest does not allow freedom of career choice between the nuclear industry and a regulatory agency. It seems that once a regulator, always a regulator – once a proponent, always a proponent – and never the twain shall meet.

Canada is very small – despite its land mass, the population is a tenth of that of the U.S.A. Yet the reactor population is a fifth of that in the States, and it is projected to grow another 30% to 50% in the next 15 years. So already we have twice as many reactors per capita as the United States and it could become, very shortly, three times as many. This requires qualified manpower. That is a major problem in Canada – while nuclear engineers are very well qualified, there are not many of them. Only three of the Universities have nuclear engineering programs. Thus, in a situation in which the Department of Energy might use a staff of 80, AECL currently might do the comparable job with 5 or 10. On the other hand, there are no inhibitions in the "revolving door" career moves between AECL, the utilities, and the AECB. This may be directly because of a lack of overall resources, but it makes for very knowledgeable regulators, and proponents.

"There are no inhibitions in the 'revolving door' career moves between AECL, the utilities, and the AECB."

All staff-level meetings are closed, material is generally not available to the public (even though there is a public document room), and the Freedom of Information Act is more restrictive in Canada than in the U.S. This means that meetings with the AECB staff are very easy to establish – generally it takes a phone call and a couple of hours notice – and the meetings with staff are very relaxed. Each side speaks very frankly without having to act their parts in the presence of nuclear intervenors. That's a much healthier atmosphere than the adversarial across-the-table meetings that are current in the U.S. Of course, there are occasions in which sides are taken and maintained between the proposers and the regulators, but in the majority of cases these meetings with staff are frank and honest.

Reactor Operation

At Chalk River the NRX and NRU research reactors have been operating for over 40 years. NRU is expected to continue to 2010 and beyond, providing a vital facility for power reactor research. A new reactor to replace NRX, the 10 MW MAPLE-X10, is currently being constructed on adjacent ground. The operators for these AECL reactors have a great deal of varied experience which is the basis for safe operations. Following the 1979 TMI event, the U.S.NRC has written and given operator examinations. The AECB staff have been doing the same – although from a much earlier period. The AECB also gets involved in operations in one further way, at least for power reactors; they approve the appointment of the Station Manager, the Production Manager, and the Station (or Senior) Health Physicist. They started this close involvement following the NRX accident back in 1952.[3] In passing, I have to wonder why the U.S.NRC didn't notice this was happening in the 27 years between 1952 and 1979.

While the U.S.NRC audits operations through Regional Office teams, and they prepare annual performance reviews, allowing their subsequent concentration on poor performers, the AECB approach is different. Again, it is more collegial. On-site resident Project Officers monitor operations, and they have the power to approve on request, on the spot, such things as minor changes to emergency procedures, trip set-point changes, changes for physical security or fissionable substances, and putting into service of certain equipment. They do not conduct a continuous compliance inspection and there are no set financial penalties for violations, although they can go to court to levy fines if need be. The AECB's major stick is the suspension of licenses (as at Bruce Nuclear Power Station in 1988), withholding licenses (as at Darlington Nuclear Power Station in 1989), or withholding license renewals, since they are only valid for two to five year durations. A minor stick of the AECB is to renew licenses for shorter periods – 2 years for "the good guys"; one year for those needing additional "encouragement". Also specific license conditions may be applied. However, as Ahearne noted in his review paper, Canadian reactor safety is ensured by the nuclear family – the utilities, especially Ontario Hydro, AECL, and the AECB, working together. This is very different from the court-room atmosphere which exists, and which is probably necessary, in the larger U.S.A., where there are many more diverse organizations with responsibilities in the assurance of nuclear safety.

The three Canadian nuclear utilities (Ontario Hydro, New Brunswick Power, and Hydro Quebec) intend to join the World Association of Nuclear Operators (WANO) as full dues-paying members, under the auspices of the CANDU Owners Group (COG). This latter organization is one which includes all international utilities who operate CANDU reactors and who share a common on-line data base of operational and research information. Presently, CANDU reactors are operating or are under construction in Argentina, South Korea, India, Pakistan, and Romania (Table 2). The CANDU Owners' Group (COG) is the equivalent of INPO in some ways – reactor experience is distributed rapidly across the world. However, COG does not have the power of INPO to control operations. The common sharing of knowledge through COG and the joint responsibility of this owners group is one reason for the excellent showing of CANDU reactors on any tabulation of reliability – typically five or six CANDUs[4] appear in the world top ten listing for the performance of large operating reactors each year. I would expect this sort of reliability of operation to be exhibited in the planned world population of small reactors.

While computerized control systems were first used in the Pickering reactor design, the most recent Darlington reactor design employs computerized control *and* shutdown systems.[5]

In the control area, programmable controllers:

- simplify the implementation of logic changes,
- allow logic testing with simulators
- simplify check-out and testing by providing on-board diagnostic software, and
- assist maintenance by monitoring alarms and indications covering field device status, output signals, ground-fault detection, and board problems.

In the safety area, microprocessors have been used in the dedicated reactor shutdown systems ... the first a rodded system and the second a liquid gadolinium nitrate injection into the heavy water moderator. The logic is 2 out of 3, using general coincidence logic in the rodded system for reliability and local coincidence logic in the injection system to avoid expensive spurious trips involving liquid poison injection. At Bruce, the use of microprocessors was limited to display and monitoring, but in Darlington each shutdown system has three trip computers (one per channel), three display and test computers (also one per channel), and a safety system monitoring computer. The trip computer monitors safety parameters against setpoints, performs setpoint modification, and alarm and trip seal-in functions. The display and test computers receive their information through fibre optic isolation links from the trip computers. The test computer can transmit signals to the trip computers and monitor their response to confirm correct operation.

This use of computerized safety systems has been approved by AECB for Darlington 1 following extensive line-by-line review of the software used. During this time the issue of adequate quality assurance for control and safety software has been the subject of a lot of discussion between Ontario Hydro, the utility owner of Darlington, and AECB.

"I have yet to see a proponent ... judge himself as rigorously as an outside reviewer."

The new CANDU 3 design builds on the reliability of the earlier CANDUs. Its major components are identical in design. However, because it is smaller, only half the number of components are required. Furthermore, the station is of modular design: each of its sections, which will be received complete and tested from off-site fabricators, weighs no more than 300 tons – easily handled by today's heavy-lift cranes. Thus, the CANDU 3 will require only 35 months from the start of construction to being ready to go into service. Two CANDU 3 units are competitive with the larger units and can produce electricity in a shorter time. Moreover, they are expected to appeal to developing countries, those with smaller electrical grids, and those without a nuclear infrastructure. The first CANDU 3 450 MWe unit is expected to be built in New Brunswick with an in-service date of 1996, and a second has been suggested for the 1997 time frame. The design is currently being reviewed by the AECB.

In the United States, in December 1988, AECL formed a subsidiary, AECL Technologies, ultimately to obtain a construction license for the introduction of CANDU into the U.S. market. To this end, AECL Technologies has submitted a licensing review basis document to the U.S.NRC for the CANDU 3 to seek design certification under 10 CFR Part 52. It is AECL's intention to comply with the requirements established by EPRI and the U.S. utilities for future nuclear plants.

Defence Activities

There is one area in which the responsibilities of the AECB and the U.S.NRC are identical. Neither agency is responsible for the safety review of defence facilities, even though they are, on occasion, called in for an opinion. The position is more critical within the U.S. because of the extent of non-commercial nuclear activities.

To my mind, this separation of responsibilities is detrimental to the interests of the public since both agencies were established to act as guardians of public health and safety in nuclear matters ... on one hand we are pledged truly independent safety assurance by the separation of proponent from regulator (remember the uproar when, finally, the old Atomic Energy Commission relinquished its self-regulatory role?) but on the other hand we are asked to believe that the Defence organization in Canada and the Departments of Energy and Defence in the U.S. are each responsible enough to act simultaneously as defendant and judge. As a member of the public I believe I have a right to the same assurance of safety whether the reactor is behind the fences of Yankee Atomic or whether it is behind the fences of Savannah River. At the present time I have not. I have yet to see a proponent, even with the best will in the world, judge himself (or herself) as rigorously as an outside reviewer might.

A case in point. The Fast Flux Test Facility (FFTF) is a Department of Energy facility certified by the Department and complying with DOE orders. During its construction it underwent a review by the U.S.NRC and several meetings were held with the Advisory Committee on Reactor Safeguards (ACRS). The views expressed by these bodies were considered. In a number of difficult (and costly) cases the Department chose to reject the advice. Thus, for example, the seismic requirements, the tornado hardening of heat removal systems, and the protection from severe accidents, were selected by the proponent. Even today there is an empty volume below the reactor vessel which we call the ACRS room ... it was destined for some sort of a core debris catcher that was not installed. The FFTF is an excellent facility with a proud and safe operating history and these proponent decisions have not proved to be wrong in the lifetime of the facility (although I understand that further tornado hardening was added at a later stage). However, to my knowledge, during the design and construction of that facility there was no healthy meaningful questioning of proponent decisions which *required* resolution.

"The U.S. system is legal and adversarial, while the Canadian is collaborative."

The American Nuclear Society, devoted strictly to the peaceful uses of all nuclear science and technologies, recently decided that it could not ignore new developments in the design of a new Production Reactor and projected space reactors and that it should welcome information exchange on those subjects. This was not only because it is the only game in town, but also because the Department of Energy could probably do with some assistance in assuring the safety and operability of any new system it plans ... especially within today's levels of public acceptance. The ANS is exercising its moral responsibility towards the advancement of nuclear science and technology in this way.

Chernobyl showed us very dramatically that the results of a reactor accident can affect other nations, those neighbouring and even those on the other side of the globe. Both the AECB and the U.S.NRC are actively working responsibly with the IAEA in establishing world requirements and standards for safety. Both agencies correctly view their responsibilities as extending to those reactors in *other* people's back yards.

Having said that, I hope that the Chairman of the Nuclear Regulatory Commission will be able to tell us that he is also discharging his public moral responsibility *within* the United States by not neglecting those reactors, and other nuclear facilities, in the backyards of Department of Defense and Department of Energy. They are *at least* as likely to affect us, the public, as those power plants in East Germany and the Soviet Union.

Summary

Both regulatory systems work well for the country and the attitudes which they serve. They are different, if for no other reason than the size and diversity of the programs which they serve. The U.S. system is legal and adversarial, while the Canadian is collaborative. Both have advantages and drawbacks.

However, the nuclear world is well aware that what is done in one country can affect others. Thus, current trends are towards a unified international approach, both in markets and in licensing regulations. Both AECL and the AECB work closely with the International Atomic Energy Agency (IAEA) in developing design and safety analysis guidelines which may, later, following experience, form the bases for rule-making. The Canadian regulator is coming closer to the U.S.NRC version by codifying its rules and criteria. Nevertheless, while assuring the safety of the public and the operator to the same high level of assurance as in the U.S., the Canadian regulatory scene is likely to retain its individual collegial framework.

Notes

1. 1,100 CFR pages of regulations and 141 Regulatory Guides on power reactors.
2. One regulatory document, four consultative documents, and a six-page siting guide.
3. The NRX accident on December 12th, 1952, was an inadvertent criticality resulting from an opening of shut-off rod air-system valves, in error, during a test sequence to compare irradiated and non-irradiated fuel bundles. This was compounded by miscommunication which resulted in yet more rods being withdrawn rather than inserted. An explosion occurred but the reactor was eventually made subcritical by dumping the heavy water moderator. Extensively damaged components, including the calandria, were removed and the reactor was put back into operation in 14 months. The reactor, which was designed for 5 years service life, has now been in service for 43 years.
4. As of December 30, 1988, six of the top ten of the world's large operating reactors (over 500 megawatts) were CANDUs.
5. David Mosey, "Darlington NGS Utilizes New Computer Controls for Shutdown System", *Electricity Today*, Vol. 1, No. 5, pp. 16-18, December 1989.

CANADIAN NUCLEAR SOCIETY

Events Calendar
Calendrier des Activités

This program lists events which are sponsored, co-sponsored or considered to be of interest to the members of the Canadian Nuclear Society

Les événements de cette liste sont organisés ou commandité par la Société Nucléaire Canadienne, ou sont considérés d'intérêt pour ses membres

Chairman-Program Committee / Président, Comité du Programme William I. Midvidy

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

1991

11-14 AUGUST 1991
15th Biennial Topical Meeting on Reactor Operating Experience: (Ready for 2000)
Seattle, Washington, U.S.A.
Main Sponsor: ANS

CONTACT:
Ms K.M. Tominey
P.O. Box 999
Richland, Washington 99352
U.S.A. 509-375-2878

25-27 AUGUST 1991
16th Annual Nuclear Simulation Symposium
St. John, New Brunswick

CONTACT:
P.D. Thompson
The New Brunswick Electric Power Comm.
Point Lepreau Generating Station
P.O. Box 10
Lepreau, N.B., Canada
E0G 2H0 506-659-2220

4-6 SEPTEMBER 1991
16th Uranium Institute International Symposium
London, U.K.
Main Sponsor: The Uranium Institute

CONTACT:
Symposium Secretariat
Concorde Services Limited
10 Wendell Road
London W12 9RT
U.K. 081-743 3106

15-18 SEPTEMBER 1991
AI '91: Frontiers in Innovative Computing for the Nuclear Industry
Jackson, Wyoming, U.S.A.
Main Sponsor: ANS

CONTACT:
Thomas K. Larson
EG&G Idaho Inc.
P.O. Box 1625, MS 1206
Idaho Falls, Idaho 83415-1206
U.S.A. 208-526-9653

29 SEPTEMBER - 4 OCTOBER 1991
Fourth Topical Meeting on Tritium Technology in Fission, Fusion, and Isotopic Applications
Albuquerque, New Mexico, U.S.A.
Main Sponsor: Los Alamos National Laboratory

CONTACT:
John Bartlit
Los Alamos National Laboratory
P.O. Box 1663, MS C348
Los Alamos, NM 87545
U.S.A. 505-667-5419

21-26 OCTOBER 1991
ASME 3rd Joint International Waste Management Conference
Seoul, Korea
Main Sponsor: ASME

CONTACT:
Radovan Kohout
Ontario Hydro
700 University Avenue, H11A20
Toronto, Ontario, Canada
M5G 1X6 416-592-5384

10-13 NOVEMBER 1991
Nuclear Energy Forum
San Francisco, California, U.S.A.
Main Sponsor: USCEA

CONTACT:
Conference Office
U.S. Council for Energy Awareness
1776 I Street, N.W., Suite 400
Washington, D.C. 20006-2495
U.S.A. 202-293-0770

10-15 NOVEMBER 1991
ANS Winter Meeting
San Francisco, California, U.S.A.

CONTACT:
Meetings Department
American Nuclear Society
555 North Kensington Avenue
La Grange Park, IL 60525
U.S.A. 708-352-6611

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1992

12-16 APRIL 1992
8th Pacific Basin Nuclear Conference
Taipei, China
Main Sponsor: Nuclear Energy Society

CONTACT:
Nuclear Energy Society
67, Lane 144, Keelung Road, Sec. 4
Taipei, Taiwan 10772
China 886-2-3628349

17-22 MAY 1992
Eighth World Congress of the International Radiation Protection Association
Montreal, Quebec
Organized by: International Radiation Protection Association

CONTACT:
Jean-Pierre Gauvin
2155 Rue Guy,
Bureau 820
Montreal, Quebec, Canada
H3H 2L9 514-932-9552

25-29 MAY 1992
Workshop on Radiation Safety in Uranium Mining
Saskatoon, Saskatchewan
Main Sponsor: Gov't. of Saskatchewan

CONTACT:
L.D. Brown (Sask. Gov't.)
Saskatchewan Human Resources, Labour and Employment
1870 Albert Street
Regina, Saskatchewan, Canada
S4P 3V7 306-787-4486

JUNE 1992
CNA/CNS Annual Conference
St. John, New Brunswick

CONTACT:
Canadian Nuclear Society
144 Front Street West, Suite 725
Toronto, Ontario, Canada
M5J 2L7 416-977-7620

7-12 JUNE 1992
ANS Annual Meeting
Boston, Mass., U.S.A.

CONTACT:
Meetings Department
American Nuclear Society
555 North Kensington Avenue
La Grange Park, IL 60525
U.S.A. 708-352-6611

20-25 SEPTEMBER 1992
15th Congress of the World Energy Council
Madrid, Spain
Organized by: World Energy Council

CONTACT:
E. Philip Cockshutt
CANWEC
Suite 305, 130 Albert Street
Ottawa, Ontario, Canada
K1P 5G4 613-993-4624

25-29 OCTOBER 1992
International Conference on Design and Safety of Advanced Nuclear Power Plants
Tokyo, Japan
Main Sponsor: AESJ

CONTACT:
Prof. Y. Oka
Nuclear Engineering Research Laboratory
7-3-1 Hongo
Bunkyo-Ku, Tokyo, Japan

15-20 NOVEMBER 1992
ANS Winter Meeting
Chicago, Illinois, U.S.A.

CONTACT:
Meetings Department
American Nuclear Society
555 North Kensington Avenue
La Grange Park, IL 60525
U.S.A. 708-352-6611

1993

3-8 OCTOBER 1993
World Congress on Nuclear Energy "Towards a Better Future"
Toronto, Ontario
Organized by: CNA and CNS
Joint sponsorship: ANS, IAEA, *et al.*

CONTACT:
Canadian Nuclear Society
144 Front Street West, Suite 725
Toronto, Ontario, Canada
M5J 2L7 416-977-7620

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TORONTO, ONTARIO, CANADA
M5G 1P7 416-977-7620

(Effective August 1, 1991)
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M5J 2L7

Canadian Nuclear Society

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SECTION LOCALE À LAQUELLE VOUS DÉSIREZ APPARTENIR

- ☐ BRUCE
- ☐ CHALK RIVER
- ☐ CROISSANT D'OR (Hamilton)
- ☐ MANITOBA
- ☐ NOUVEAU-BRUNSWICK
- ☐ OTTAWA
- ☐ QUÉBEC
- ☐ SASKATCHEWAN
- ☐ TORONTO
- ☐ LAC ONTARIO CENTRAL (Pickering, Darlington, Port Hope, Peterborough)
- ☐ ÉTATS-UNIS ET INTERNATIONAL

DIVISION TECHNIQUE À LAQUELLE OU AUXQUELLES VOUS DÉSIREZ APPARTENIR

- ☐ SCIENCE NUCLÉAIRE ET GÉNIE CIVIL
- ☐ CONCEPTION ET MATÉRIAUX
- ☐ EXPLOITATION MINIÈRE, FABRICATION ET EXPLOITATION DES CENTRALES
- ☐ GESTION DES DÉCHETS RADIOACTIFS ET ENVIRONNEMENTAUX

TYPE D'ADHÉSION ET COTISATION POUR 1991†

☐ RÉGULIER	55.00$††
☐ FONDATEUR	55.00 ††
☐ ÉTUDIANT(E)	20.00
☐ RETRAITÉ(E)	30.00
☐ INSTITUTIONNELLE	55.00

† Les membres qui enverront leur application après le 1er septembre 1990, seront automatiquement transférés à l'année 1991/92. Les frais de la TPS sont inclus dans les frais d'inscription.
†† Seulement les membres réguliers et fondateurs ont le droit au vote.

METHODE DE PAIEMENT

☐ CHEQUE ☐ VISA ☐ MASTERCARD ☐ AMEX

NUMÉRO DE CARTE ____________

DATE D'EXPIRATION ____________ SIGNATURE ____________ DATE ____________

Veuillez faire parvenir votre paiement, incluant le numéro de facture, le plus tôt possible. Les paiements par carte de crédit peuvent être envoyés par télécopieur au (416) 979-8356. Un reçu officiel sera expédié dans les plus brefs délais.

Langue de préférence pour correspondance ☐ Français ☐ Anglais (English on reverse side)

Veuillez compléter et retourner à
Société Nucléaire Canadienne, 144, rue Front ouest, Ste 725, Toronto, Ontario M5J 2L7
Téléphone (416) 977-7620