CANADIAN NUCLEAR SOCIETY

bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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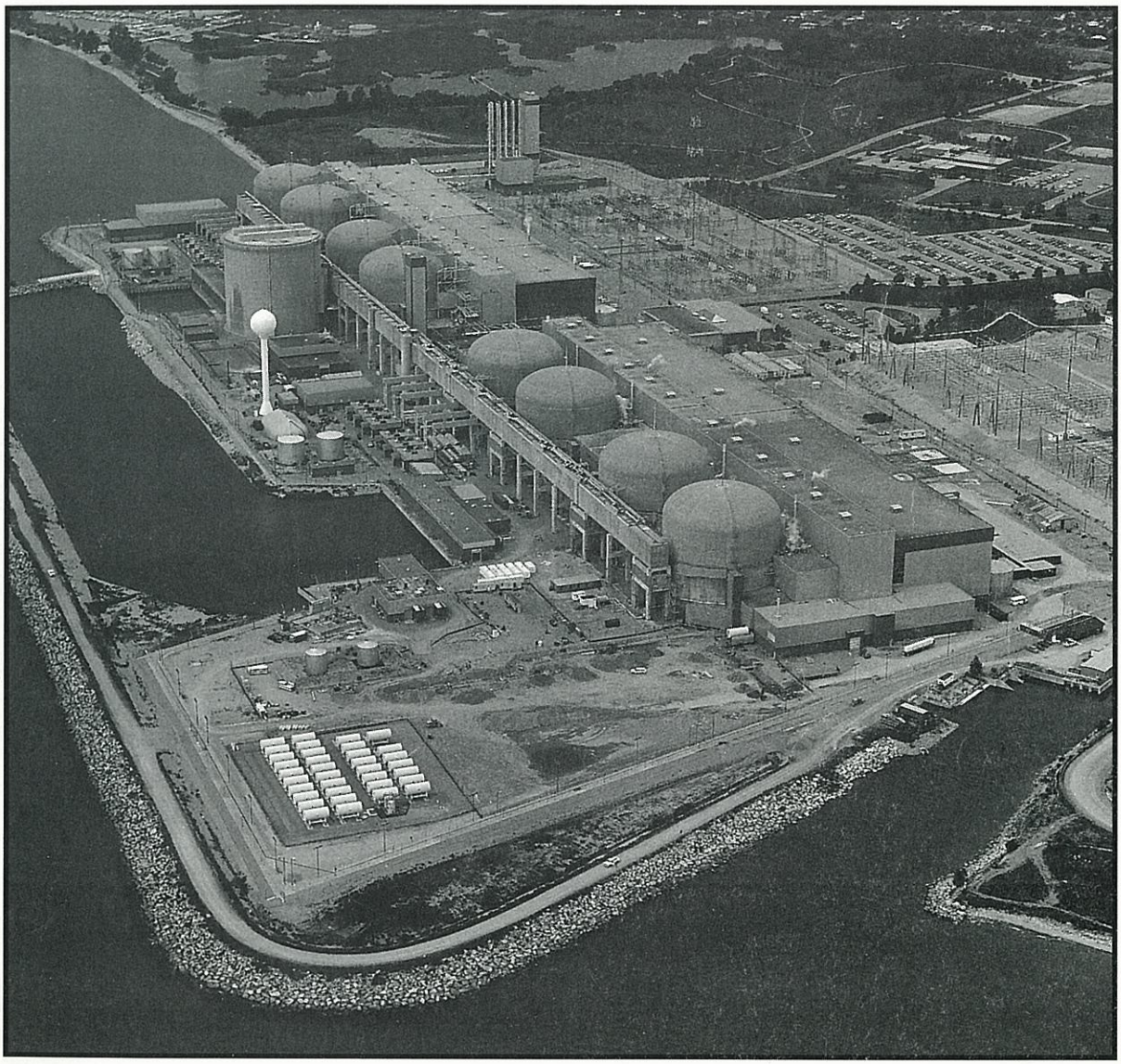

- Chernobyl revisited
- CANDU Maintenance Conference
- Winter Seminar
- Effect of low doses

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Cover Illustration

The cover photograph is an aerial view of Pickering NGS to mark the 25th anniversary of the start-up of unit 1.

(Photo courtesy of Ontario Hydro)

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

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EDITORIAL

TIME TO REFLECT

This is a year of nuclear anniversaries, some happy some not so.

First there is the centennial of the discovery of radioactivity in 1896 by Henri Becqueral which opened up the new science which we now embrace with the term "nuclear". Like the discovery of X-rays by Wilhelm Roentgen the year before this revolutionary knowledge was, in general, widely hailed. In fact it was embraced to the point that the first errors in use occurred with widespread application of X-rays for frivolous purposes and activities such as bathing in "radium waters". It was over two decades before the harmful aspects of radiation were widely acknowledged and steps taken to control its use.

Then we have the golden anniversary of our nuclear regulator, the Atomic Energy Control Board. While there are probably some in the Canadian nuclear community who would argue that is not something to celebrate we would argue that Canada has been fortunate to have one regulatory agency over the entire history of our nuclear program and that, in general, the AECB has been a reasonably intelligent and objective regulator.

On an indisputably happy note, we have the silver anniversary of the start-up of the first unit of the Pickering NGS. That truly was a remarkable achievement given the relatively short history of our nuclear program at the time and was a great leap of faith for the organizations involved. The only sadness associated is the fact that most of the pioneers who made that event a reality are now retired and some have left us permanently.

The most recent anniversary, that of the Chernobyl disaster of 1986, is a very sobering one. Despite the decade since that tragic event it still lingers in the perspective of most people when they think about nuclear energy. There is no easy way to erase such a negative image from the collective memory but we should be prepared to put the event into perspective. There have been many, more disastrous accidents in other industries: such as the Bhopal chemical plant explosion in India in 1984 that killed 2850 people and injured over 200,000; a natural gas explosion in Mexico City in 1984 that killed over 500 and injured more than 4200; and the sliding of a coal waste pile in Wales in 1966 which killed 147 of which 116 were children.

While such comparisons show that nuclear energy has been comparatively very safe that is not a sufficient argument. Regardless of the standard achieved compared to other industries, efforts must continue to make the use of nuclear energy, in all of its applications, increasingly safe. That can be done through approaching all activities in a disciplined fashion. The increasing application of the ISO 9000 international quality assurance standards is a good step in that direction.

IN THIS ISSUE

We begin this issue with a **Letter to the Editor** on a controversial topic of which many readers will be unaware.

Our lead article, **Chernobyl Revisited,** is a retrospective look at the accident of April 1986; not out of nostalgia but from a sense of need to prepare for what may be a media attack on nuclear science and technology prompted by the 10th anniversary of that disastrous event.

That is followed by two papers dealing with the issue of the effect of low doses of ionizing radiation on humans. The first is an exhortation and cogent argument by CNS president Jerry Cuttler in his paper **Overcoming the Fear of Radiation.** This is followed, for context, by a background paper on the **Biological Effects of Low Doses.**

Then we have reports and some papers from two recent meetings. There is an overview of the very successful **3rd CANDU Maintenance Conference** held last November followed by a paper by Ted Dunstan on the AECB's perspective on **Maintenance of Ageing Reactors** and one on **Mobile Robotics for CANDU Maintenance** which we hope may even interest those not into that field.

A summary of the interesting and informative **CNA/CNS Nuclear Winter Seminar** held in early February is presented for those unable to attend. This is accompanied by two of the presentations, **New Initiatives at the AECB** and **Women in Nuclear.** (No apologies are offered for selecting papers from AECB speakers from both meetings; the influence of the regulator is pervasive and it is important to understand where it is and where it is going.)

Again we have some items of **General News** that readers may not have seen elsewhere and our usual extensive section on **CNS News** with happenings of the society and its members.

The issue is rounded out with two **Book Reviews,** the ever growing event **Calendar** and, fortunately, the **Anniversary Crossword** by Keith Weaver which got lost in the shuffle of the last issue. And then, to close, there is the difficult to categorize **Darker Side.**

As always we thank all of our contributors and extend our invitation and wish for your comments.

DEADLINE

The deadline for the next issue, which will be published about the end of May, will be **Friday, May 3, 1996.**

The Folly of Russian Molybdenum

Ed. Note: *To provide some context for the following letter an article in the Ottawa Citizen, 31 January 1996, reported that a small Ottawa company, Candesal Inc., was negotiating with a Russian organization, the Institute of Physics and Power Engineering in Moscow, for the supply of Molybdenum 99. This was subsequently confirmed, a vice-president of the company. The principals of Candesal formed a new company, RCT (for Russia Canada Technologies), to pursue the venture.*

Technetium 99m, a radioactive daughter of Molybdenum 99 is used extensively in many diagnostic procedures in nuclear medicine, with, reportedly, over 30,000 such procedures daily. Since Mo 99, which is produced by irradiating U 235 targets has a half life of only 66 hours production and distribution must be essentially continuous.

AECL's NRU reactor is currently the source of over 80 per cent of the western world supply of Mo 99, which is distributed by Nordion International. Given the age of NRU, concerns have been expressed about its long-term reliability as a supplier and proposals have arisen in the USA and Europe to build a competing source. After some serious legal arguments, AECL and Nordion are reportedly nearing the completion of an agreement for the construction of two MAPLE reactors at Chalk River Laboratories dedicated to the supply of isotopes, primarily Mo 99.

The Editor

RCT (Russia Canada Technologies) has proposed that the feedstock for Nordion International's molybdenum sales be changed from the current practice, namely production in NRU at Chalk River, to being provided from Russian sources.

While likely beneficial to the principals of RCT, I would like to point out five good reasons (among others) why both Canada and the Canadian nuclear industry would suffer terribly from this folly.

(1) Stability of supply: Due to the relatively short half-life of molybdenum 99, stability of supply in the production chain is imperative. Due to the ever turbulent Russian political scene a sure and steady supply simply cannot be guaranteed.

(2) Perception of customers: It is this very need for an assured supply, something AECL cannot guarantee without a replacement for NRU, that has introduced the very real possibility that the USA and other countries may re-enter the business of producing molybdenum. This would prove disastrous for both Nordion and AECL.

(3) Environmental consequences: It is well known that Russian standards for storage and disposal of radioactive waste lag far behind Western standards. The waste stream from the molybdenum production process in Canada is carefully managed. Without safeguards similar to those in place in Canada serious environmental problems are bound to occur.

(4) Stability of pricing: Although the pricing for Nordion's feedstock is currently under review, it is stable and not subject to large swings. A switch to Russian sources which would in all probability lead to curtailment of production in Canada, would leave both Nordion and its customers susceptible to price fluctuations.

(5) Employment: The current negotiations between Nordion and AECL to establish a new pricing and production basis will, by best accounts, result in the construction of new isotope production facilities at Chalk River. This will bolster employment in Canada at a time when power reactor orders are low. A switch to Russian sources, resulting in the cancellation of these facilities would have a negative short term impact on domestic employment. A longer term negative impact on export sales of isotope production technologies is also a very real possibility.

AECL and Nordion are showcases of Canadian technology. They have earned their distinctions well. It would be a shame to cause serious technical and financial harm to these companies for the sake of opportunistic profits.

Terry Jamieson

Canadian Nuclear Society 17th Annual Conference

Fredericton, New Brunswick

9 - 12 June 1996

The 17th Annual conference of the Canadian Nuclear Society will be held in Fredericton, New Brunswick, from the 9th to 12th of June 1996, in conjunction with the 36th Annual Conference of the Canadian Nuclear Association.

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Chernobyl Revisited

The upcoming 10th anniversary of the Chernobyl disaster is recognized as a potentially difficult time for the nuclear community worldwide. In Canada representatives of the major nuclear organizations are working under the auspices of the Canadian Nuclear Association to produce a Canadian statement. Unfortunately, that document was not ready in time for this issue of the CNS Bulletin; *hence this special article compiled by the editor from a number of sources.*

Overview

In the early hours of 26 April 1986 two explosions blew apart the reactor and building of unit 4 at the Chernobyl nuclear power station about 130 km north of Kiev in the Ukraine, then part of the USSR. The explosions and consequential fire released a large amount of radioactive material into the atmosphere (one estimate states more than 50 million curies) over the following two weeks. With the initial prevailing winds blowing towards the northwest this material was carried over the Ukraine, Belarus, eastern Europe and Scandinavia. Later the plume shifted so much of central Europe and the Balkans were affected.

The Chernobyl complex consisted of four RBMK 1000 nuclear units; two completed in 1977 and two in 1983. Two more units were under construction at the time of the accident.

The damaged unit was covered up with sand and sealed with a concrete "sarcophagus" over the next few months, which has essentially contained the destroyed reactor until now, although it is reportedly deteriorating and beginning to leak.

The health effects are still somewhat contentious. A total of 31 persons died directly from the accident, 28 from radiation exposures as high as 16 Gray. A large group of "liquidators" (as many as 600,000 persons who were involved in controlling the accident, decontamination, sarcophagus construction and other recovery operations) received doses ranging up to 250 mSv.

Evacuees and persons living in the contaminated areas of the former USSR received whole body doses estimated to average about 15 mSv and thyroid doses (from radioiodine) ranging up to 40 Gy. The most serious consequence from this exposure has been a large increase in thyroid cancer among children in the most highly contaminated areas. About 700 excess cases had been identified by late 1995. There have been, however, few deaths attributed to these thyroid cancers. No identified increase in leukaemia or other radiation induced diseases, which can be attributed to the accident, has occurred in the former USSR or other countries receiving fallout .

The accident spawned many studies, conferences and even some new organizations. The International Atomic Energy Agency created its International Nuclear Safety Advisory Group (INSAG) whose first report in late 1986 (INSAG 1) dealt with lessons from Chernobyl. INSAG produced a further report (INSAG 7) seven years later in 1993. In the first report INSAG attributed the accident entirely to operator error. In the latter it stated that design faults were equally to blame.

The Chernobyl reactors are of the RBMK 1000 design. They are graphite moderator, pressure-tube type of reactors using slightly enriched uranium in the form of uranium oxide. The coolant is boiling light water with direct steam feed to twin 500 MW(e) turbines. Zirconium alloy is used for the pressure tube and fuel cladding. Fuel changing is on power. A mixture of nitrogen and helium is used to cool the graphite. The core is about 7 m high and 12 m diameter.

Much has been made of the RBMK's positive void coefficient as being a major factor in the accident. CNS president Jerry Cuttler and AECL physicist Adi Dastur argue that the "root cause" was the faulty design of the control/protective absorber rods, with the positive void coefficient being a "contributing cause". The design was such that the initial action of the absorber rods was actually to insert reactivity through the action of the graphite "followers" or extensions displacing water in the guide tube within the core. The design of the shut-off rods has since been modified.

Accident sequence

The following description of the accident is largely extracted from a recent report prepared by the Committee for Radiation Protection and Public Health of the OECD Nuclear Energy Agency.

The Unit 4 reactor was to be shutdown for routine maintenance on 25 April 1986. It was decided to take advantage of this shutdown to determine whether, in the event of a loss of station power, the slowing turbine could provide enough electrical power to operate the emergency equipment and core cooling pumps until the diesel emergency power supply became operative. This test was carried out without proper exchange of information between the [test] team and operation personnel. Therefore, inadequate safety precautions were included in the test program and the operating personnel were not alerted to the safety implications of the test.

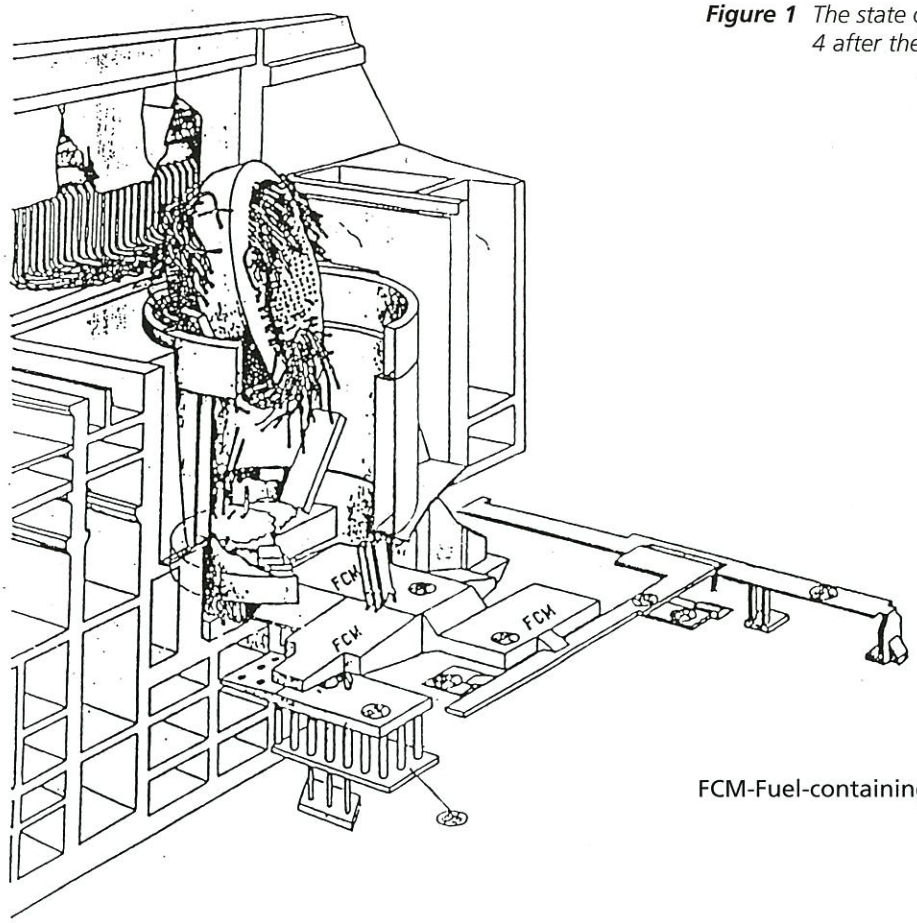

Figure 1 *The state of the reactor section of Unit 4 after the accident*

FCM-Fuel-containing masses

The planned program called for shutting off the Emergency Core Cooling System (ECCS). As the shut-down proceeded the reactor was operating at about half power when the grid controller refused to allow further shutdown. {Nevertheless} in accordance with the test program the ECCS was switched off while the reactor continued to operate at half power. It was not until about 2300 hours that the grid controller agreed to a further reduction in power.

For this test the reactor should have been stabilized at about 1,000 MW(th) but due to operational error the power fell to about 30 MW(th) where the positive void effect became dominant. The operators tried to raise power by switching off the automatic regulators and freeing all the control rods manually. At about 0100 hours 26 April the reactor was stabilized at about 200 MW(th).

Although there was a standard operating order that a minimum of 30 control rods was necessary for reactor control only 6 to 8 rods were used in the test. Many of the control rods had been withdrawn to compensate for the build-up of xenon. This meant that about 20 seconds would be required to lower control rods and shutdown the reactor.

There was an increase in coolant flow and a resulting drop in steam pressure. The automatic trip which would have shut down the reactor on low steam pressure had been circumvented. To maintain power the operators had to withdraw nearly all the remaining control rods.

The reactor became unstable and the operators had to make adjustments every few seconds. Simultaneously, the pumps (powered by the slowing turbine) were providing less cooling water. The loss of cooling water increased steam production in the channels [increasing power through the positive void coefficient].

When the operators attempted to shut-down a power surge occurred [deduced later to be caused by an injection of positive reactivity due to the faulty shut-off rod design]. The fuel ruptured and the reaction of the small hot particles with the water is believed to have caused a steam explosion. A second explosion occurred two to three seconds later possibly involving hydrogen.

The accident occurred at 0123 hours, Saturday, 26 April 1986. The two explosions destroyed the core of Unit 4 and the roof of the reactor building. *(Figure 1, taken from recent report on the "sarcophagus" depicts the deduced state of the reactor after the accident.)*

The two explosions sent a shower of hot and highly radioactive debris into the air and exposed the core to the atmosphere. The plume rose some 1.5 km into the air. Heavier debris was deposited close to the site but lighter components, fission products and noble gases were blown by the prevailing wind to the northwest.

Fires started in what remained of Unit 4. Over 100 fire fighters were called in and this group received

the highest radiation exposures. These fires were put out by 0500 hours but by then a graphite fire had started. The intense graphite fire was responsible for the dispersion of radionuclides and fission fragments high into the atmosphere. The emissions continued for about 20 days.

Very little expertise existed anywhere on fighting graphite fires. A decision was made to layer the graphite fire with large amounts of different materials, each one designed to combat a particular feature of the fire and the radioactive release. Boron carbide was dumped from helicopters as a neutron absorber to prevent any renewed chain reaction. Dolomite was added as a heat sink and a source of carbon dioxide. Lead, sand and clay were added for shielding and to prevent the release of particulate material.

An outer concrete protective wall was erected around the perimeter of the unit and other walls built to support a concrete and steel roof. A tunnel was built from unit 3 to provide cooling to the remaining core.

Health Effects

The following is taken from a recent review report, GMA - 10, "The Observed and Predicted Health Effects of the Chernobyl Accident", prepared by the Group of Medical Advisers to the Atomic Energy Control Board based on an extensive study of available literature.

Large tracts of land in the [former] Soviet Union were contaminated with radionuclides and 135,000 people were evacuated from the zone around the reactor. The intervention criteria adopted by the Soviet authorities for relocation and other protective actions are generally much lower than that suggested by western experts, thus substantially increasing the size of population subject to a remedial measure.

The majority of credible estimates of harm arising in the general population living in the contaminated areas indicate a very small increase in cancer mortality which will not be detectible. These range from a maximum of 0.02 percent down to 0.001 per cent or less. *(Ed. Note: These are all based on the linear dose-effect model.)*

A large number of children sustained high doses to their thyroid glands. In Belarus and Ukraine there has been an increase in the incidence of thyroid cancer in children which has not yet peaked.

(At a conference of the World Health Organization in late 1995 the number of cases reported were 400 in Belarus, 220 in Ukraine and 62 in Russia.) Prior to the accident the rate in Belarus was less than one case per year.

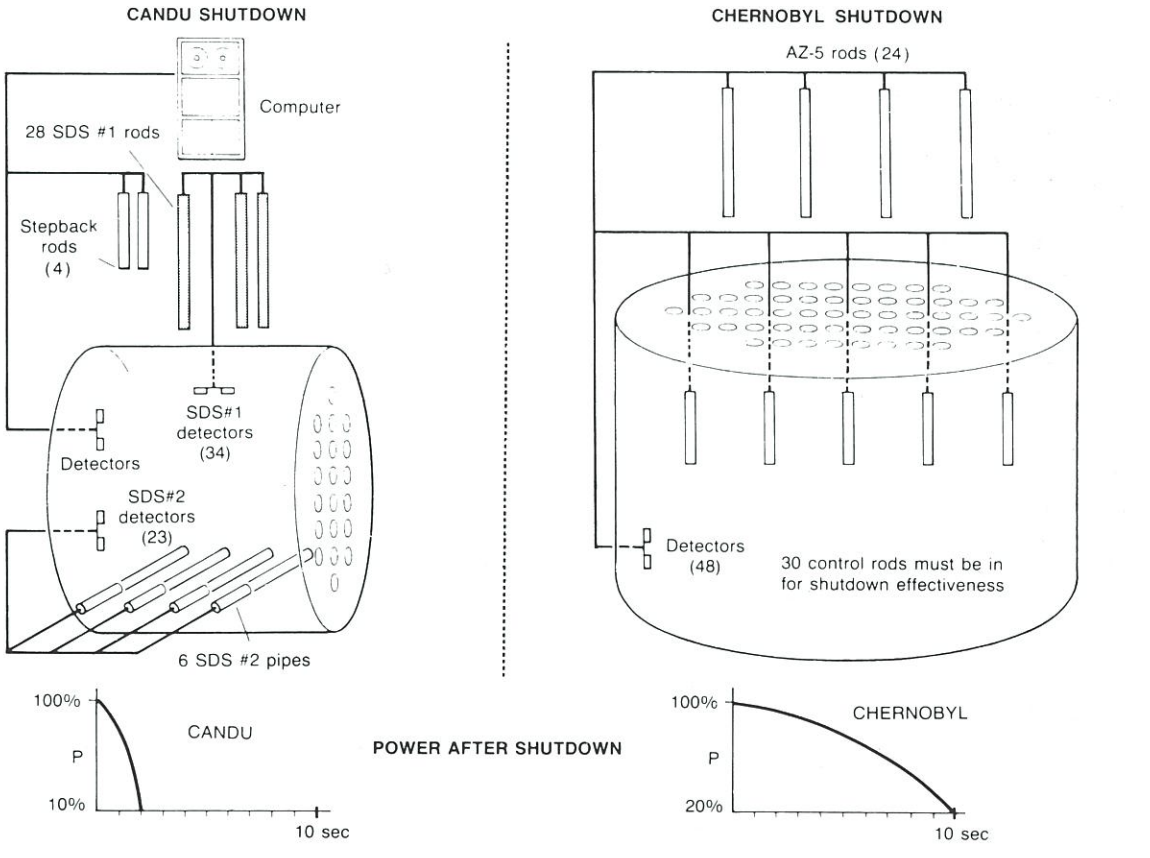

Figure 2 *Shutting down the reactor*

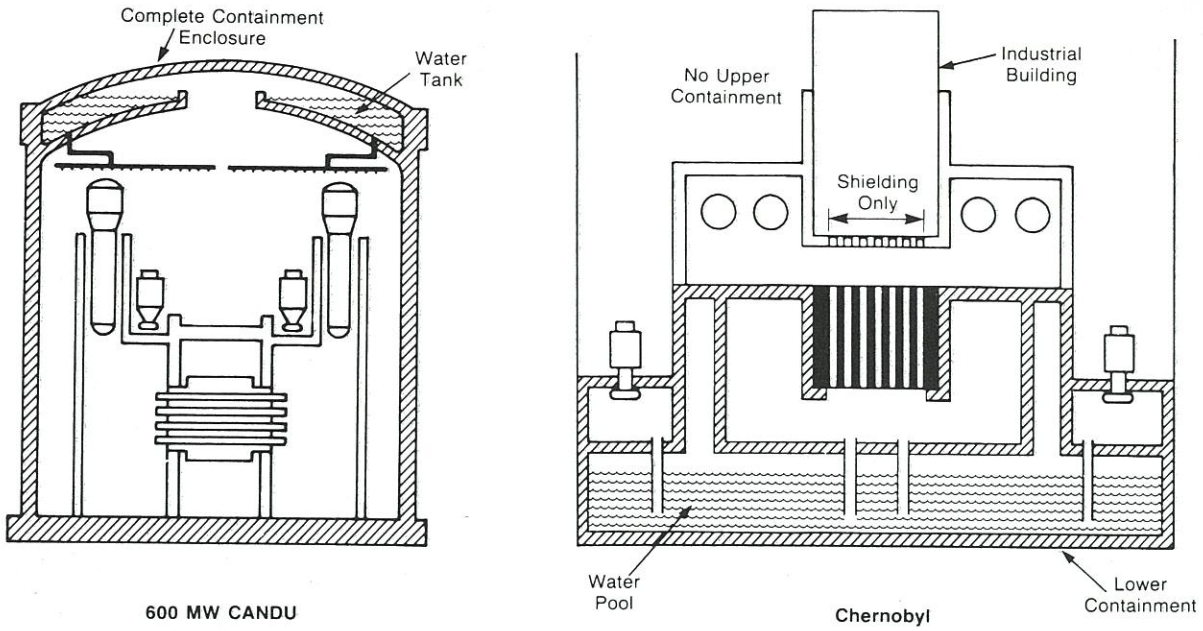

Figure 3 *Containment*

Some of the emergency accident workers received significant doses and might be expected to reveal higher cancer incidence in the future.

Psychological effects, are causing a great deal of distress. The anxiety and stress induced by the public perception of the accident are probably the most important indirect health effects.

The number of fatal cancers in the general population of western Europe [due to contamination from the accident] has been projected to increase by 0.003 per cent over the next fifty years. This is a theoretical calculation [based on the linear dose-effect hypothesis] and, if it occurs, it will be hidden in the natural statistical fluctuations.

There is fairly convincing evidence that the potential health effects in the general population are so minor as to be indiscernible.

Relevance to CANDU

The relevance of the Chernobyl accident to CANDU was reviewed in an AECL report by Vic Snell and Joe Howieson issued in 1987.

They authors noted that the major design aspects of Chernobyl which exacerbated the accident were; the slow and weak shutdown mechanism and the fact that the piping at the top of the reactor was not inside a containment structure. *(See figures 2 and 3 taken from that report.)*

On the two similarities in design; use of pressure tubes and a positive void coefficient they argued that the pressure tube design did not contribute to the Chernobyl and that CANDU has only a **small** coefficient which is easily handled by the control system and the two independent protective systems.

In summary the authors state: *The basic CANDU characteristics, the two diverse and capable dedicated shutdown systems, and the effectiveness of the containment system, lead us to conclude that the Chernobyl accident is not relevant to CANDU.*

Overcoming the fear of radiation: the key to the golden age of nuclear technology

J.M. Cuttler

Ed. Note: *The following is a preview of a paper that Dr. Jerry Cuttler, president of the Canadian Nuclear Society, intends to present at the CNA/CNS Annual Conference in Fredericton in June 1996. He gave a summary of it at the CNA/CNS Winter Seminar in Ottawa, February 6, 1996. Readers reactions are solicited.*

ABSTRACT

Canadian nuclear technology is threatened by radiophobia. It stems from the misuse of the linear dose-response model to label radiation as a carcinogen and to predict the number of excess fatal cancers to be expected from exposures to low-level radiation. Ironically, the actual response seems to be a beneficial effect due to the stimulation of the defense mechanisms that deal with both spontaneous and externally-induced cell damage. The scientific community should act to discourage improper use of the linear model and to inform Canadians of the safety of low-level radiation, to safeguard our nuclear heritage.

Impact of radiophobia on Canadian nuclear technology

Are we aware that Canada's nuclear technology and its greatest technical achievement - the CANDU reactor - are in jeopardy?

Why do I believe this is so?

It's because most Canadians have the paradigm that "nuclear radiation is a carcinogen", and they are just terrified of the big C - cancer. This response is understandable on an emotional level. As a cause of death, cancer has risen to an incidence of approximately 20 percent of the population. Teachers and the media are communicating to the next generation that nuclear technology involves radiation - a carcinogen. Today's youth will form tomorrow's governments. Would we expect them to cherish and foster our nuclear heritage?

Are we aware that one of every three patients admitted to a modern hospital receives diagnosis or treatment involving nuclear medicine techniques?[1] Are we aware that nuclear energy supplied two-thirds of Ontario's electricity in 1994?

Yes, it's a tremendous benefit to humanity, but because of radiophobia - the fear of radiation, we have great difficulty using nuclear technologies and transporting, storing and disposing radioactive wastes.

At this time, we should be celebrating the centennial of the discovery of X-rays by Röntgen. Have you heard about it? Did you know that 100 years ago, on March 1st, Becquerel discovered radioactivity? "Except, perhaps, for the Bible and Shakespeare, there is scarcely a subject that has been more closely studied than the effects of radiation on living things.... Yet most people in Canada, whether they are well educated or not so well educated, know very little, if anything at all, about radiation."[2]

Jerry Cuttler

We have mountains of data on the effects of radiation on health, but we behave as if it's all a big mystery. The effects are classified as deterministic and probabilistic. Deterministic ones cause harm (e.g. burns) to all people above certain dose thresholds, while probabilistic ones are assumed to cause delayed cancer and harmful genetic effects in some people, at any dose.[3] It is these probabilistic effects at low radiation doses that are controversial.

Origin of radiophobia

What do people generally think of first when nuclear technology is mentioned? Is it electricity or medicine or food processing? No! It is nuclear weapons, proliferation, Hiroshima, Chernobyl, radiation, cancer, etc. - negative ideas that inspire fearful images.

Why is that? Where did the paradigm (label) "radiation is a carcinogen" come from?

You don't need a university degree to understand it. High school mathematics is sufficient to explain it, and I apologize for being too mathematical.

Figure 1 is the linear, no-threshold dose-response model, taken from the 1990 BEIR Report,[4] that was developed 37 years ago by the ICRP.[5] Scientists observed delayed cancer fatalities among the survivors of the bombing of Hiroshima and Nagasaki that they could attribute to the radiation. They fitted a straight line to the cancer data for survivors who received an instantaneous exposure in the high

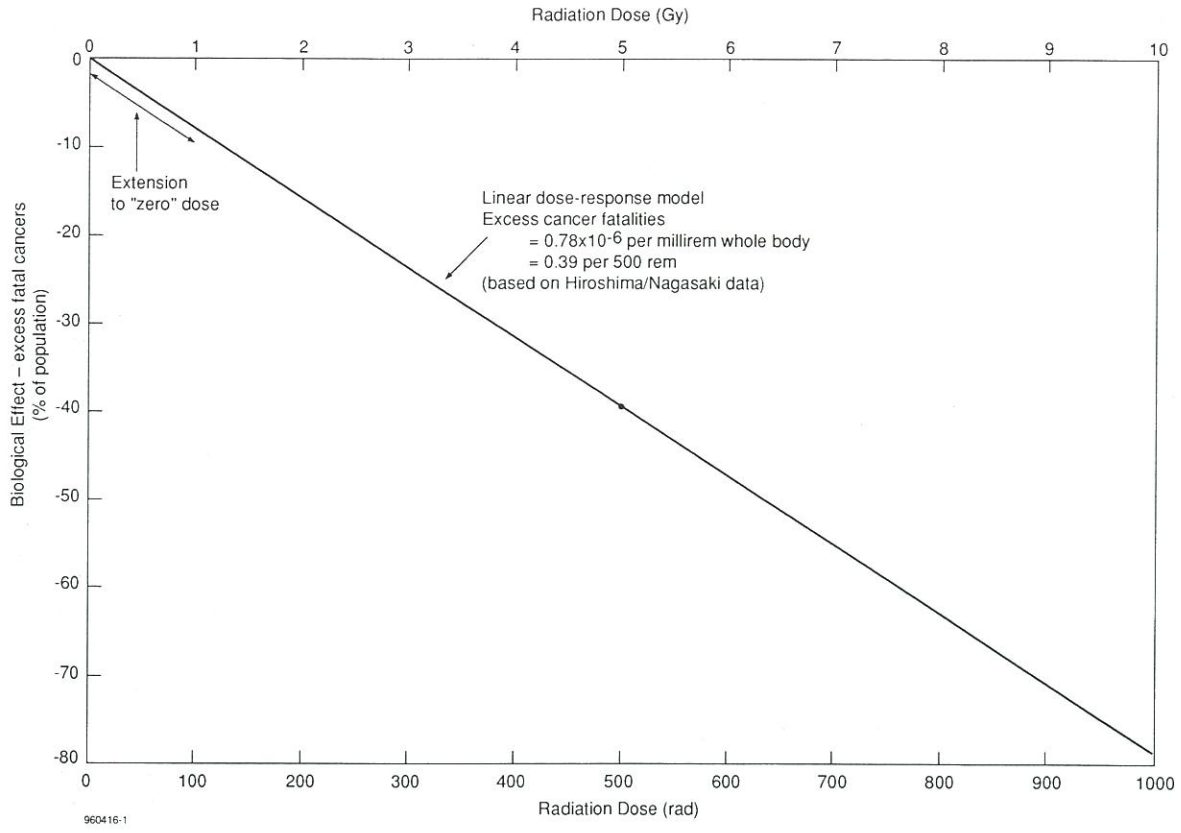

Figure #1

dose range from 1 to 10 gray (100 to 1000 rad). Then they made the assumption to extend this line ~10 percent beyond the range of the data, from 1 to "zero" gray (100 to 0 rad), to the incidence of spontaneous cancer fatalities. Enhancements, such as dose and dose rate effectiveness factors, were added to reduce the postulated cancer fatalities at low doses and dose rates, but these are often overlooked.

The radiation measurement and protection community understood that this linear extension overpredicted the expected incidence of fatal cancers in the low dose range, but they justified it as a conservative hypothesis, suitable for protecting the health of radiation workers. Some rationalized the hypothesis by simply postulating that a constant fraction of a dose would initiate tumours, assuming that the organism's defense mechanisms, that cope with cell damage, function in proportion to the dose.

The next step taken was very damaging for nuclear technology. The linear model was enshrined and used in the low-level range (where it is difficult to test due to statistical errors) to predict the expected number of "excess" fatal cancers that would result from calculated radiation exposures from hypothetical nuclear accidents. This is the basis for the radiophobia that later developed. This model has recently been used to frighten the public of tiny releases of tritium to drinking waters.[6]

Figure 2 is the dose-response behaviour, showing radiation dose on a logarithmic scale. The straight line of the linear dose-response model appears as a curve that approaches the likelihood of spontaneous cancer fatalities, typically one in five, or 20 percent of the population, as dose decreases. Statistical variations cloud the difference at low doses.

The Hiroshima/Nagasaki data ranges from 1 to 10 gray (100 to 1000 rad), instantaneous, but the straight line extension continues many orders of magnitude (factors of 10) to "zero" dose. (Natural background radiation is ~0.3 rad per year.) Since this line theoretically never reaches the spontaneous incidence of cancer, any analyst can always calculate a large number of excess fatal cancers, for a small dose, simply by multiplying the small difference between the lines by a very large population.

This is the source of radiophobia - the paradigm that radiation in any amount is a carcinogen.

The real response

So what is the reality of the response of living organisms to radiation?

First of all, humans genes have been exposed to background radiation for approximately two million years and, with all that accumulated dose, humanity seems to be improving with time.

Secondly, there is considerable evidence of beneficial health effects[7, 8, 9, 10, 11, 12] from short-term (acute) exposures up to ~50 rad, and long-term (chronic) exposures up to at least a thousand rad. This evidence appears to support the hypothesis that radiation exposures in these dose ranges actually stimu-

late defense mechanisms[13] that deal with both spontaneous and externally-induced cell damage. The rate of spontaneous DNA damage is remarkably high, ~8000 events per cell per hour, while DNA damage caused by radiation is only ~20 events per cell per rad.[14] Spontaneous events may not be equivalent to radiation-induced events, nevertheless, the defense mechanisms are very active. While small, acute doses stimulate the defense mechanisms, impairment overrides stimulation for exposures greater than 50 rad.

Thirdly, organisms can tolerate a very large dose of radiation if it is delivered gradually, in a manner that does not overwhelm the defense mechanisms. The radium dial painters accumulated considerable amounts of radium in their bones in the 1920s, yet they show no evidence of excess cancer for integrated doses up to at least 1000 rad, over their entire lives.[15, 16] As a result, the hypothesis of probabilistic harmful effects for low-level doses is being challenged.

The positive effect of subharmful doses of nuclear radiation is termed "radiation hormesis". The word hormesis is derived from the Greek word *hormaein*, which means "to excite". This is shown on Figure 2 as a beneficial effect of up to ~30 percent on the spontaneous incidence of cancer due to acute doses up to ~0.5 gray or 50 rad.

A comprehensive test of the linear model for inhaled radon decay products clearly shows that the incidence of lung cancer fatalities is lower in regions where the concentration of radon is higher.[17] The slope of the line is actually opposite to what the linear model predicts!

Unfortunately, members of the radiation measurement and protection community do not acknowledge data which indicate beneficial effects of radiation because the idea of hormesis is not compatible with the paradigm that all radiation is harmful. Scientists are reluctant to endorse the evidence on radiation hormesis for fear of ridicule and admonishment by the radiation protection establishment who support the extension of the linear model to zero dose.

The real effect of radiation on health was known to scientists when the Chernobyl accident occurred in 1986. They also knew the lifetime dose to the local population would be less than ~35 rad.[18] Nevertheless, radiophobia prevailed, and added the fear of impending cancer to the emotional stress of evacuation from homes.[19] Many thousands of abortions were performed needlessly.

The data [20, 21] demonstrate that the incidence of cancer fatalities does not exceed the incidence of fatalities in neighbouring regions, where there was much less fallout - except for thyroid cancer in children. Of the ~70,000 children who received relatively high doses (to thousands of rad each) to their thyroid glands from the uptake of iodine-131, ~600 children contracted thyroid cancer. They were treated, but three of them died of their disease.

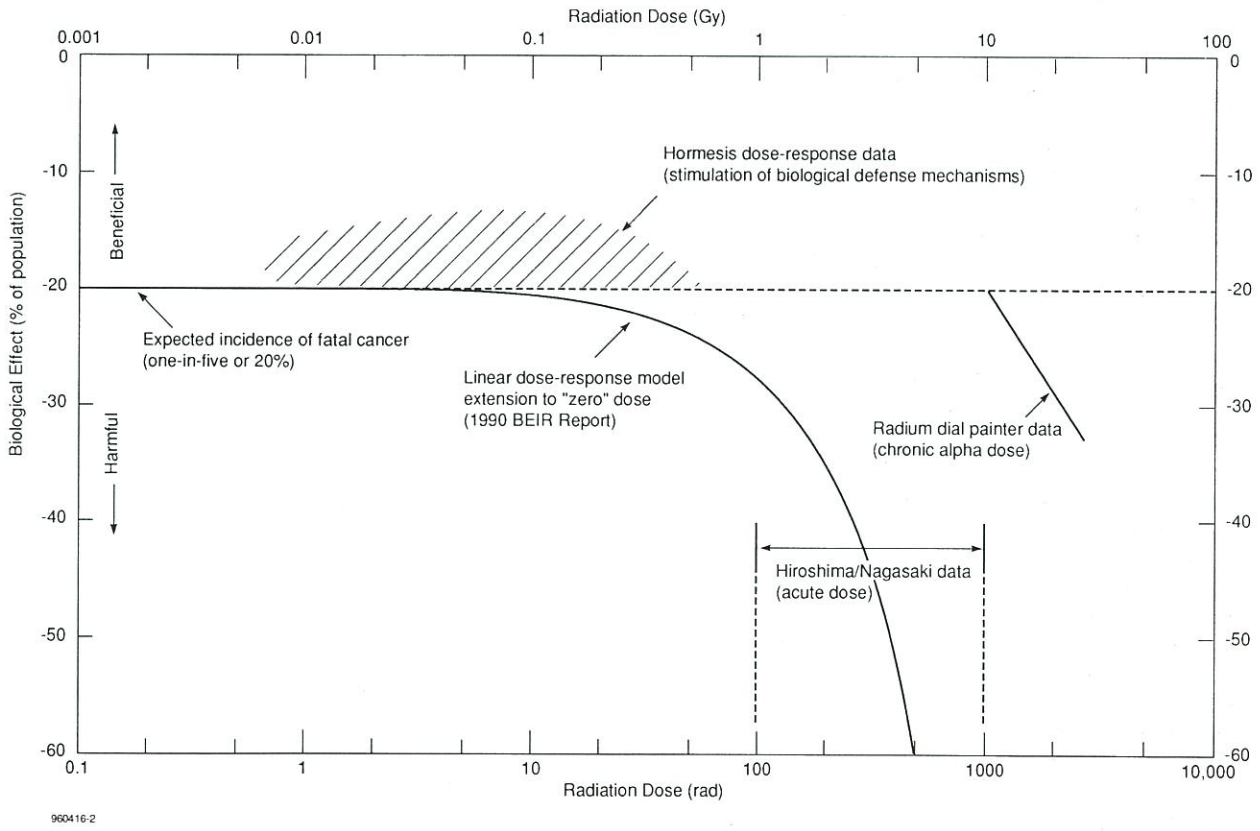

Figure #2

Aside from the emotional stress, this is the effect of the radiation from the worst imaginable accident of a nuclear power plant.

Predictions of health effects, fifty years into the future, are being made. Radiation protection practitioners calculate the increase in lifetime cancers induced in the general population to be 0.01 percent. This harmful health effect, if it occurs, will be hidden in the inherent natural statistical fluctuations of the cancer fatality data.[21] However, since radiation is known to stimulate biological defense mechanisms, beneficial health effects (lower incidence of cancer, increased life expectancy) should be expected.

April 26th will be the 10th anniversary of the Chernobyl accident. What would you expect the media to report? Will it be the good news, that the actual consequence of the radiation was much less than feared?

A need for action

We can imagine how Galileo must have felt 500 years ago when he was ordered by the priesthood of the Inquisition not to publish the theory that the planets rotate about the sun, which contradicted the established geocentric model of the universe - that the Earth is the centre of the world.

If we take no action to stop the inappropriate use of the unsubstantiated linear, no threshold dose-response hypothesis, fear of radiation will continue and the likely consequence will be the end of nuclear technology in Canada. Fear and excessive regulation will make nuclear technologies uneconomic in comparison with other, inferior options. The quality of human life will suffer.

Is it proper to inform the public of the likelihood of fatal cancer using an invalid theory? The linear, no-threshold model is not necessary for effective regulation of radiation. It should be discarded immediately. Our policy on low-level radiation should be changed.

To preserve, enhance and fully utilize our nuclear heritage, we must abandon our restraint and silence on the issue of radiophobia. We must speak out and take action to inform all Canadians that we live in a radioactive world, that all living things can tolerate moderate exposures to radiation, that low-level radiation is quite safe and even beneficial, and that it is acceptable to use nuclear technology and dispose of radioactive wastes.

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Biological effects of low doses of ionizing radiation

by Abel J. González

Ed. Note: *Over the past few years there has been a growing debate about one of the fundamental bases for radiation protection — the linear dose-effect model for low doses. To provide readers with further context for this argument we present the following article, extracted from one in a recent issue of the IAEA Bulletin, which gives an insight into the position of one of the most influential bodies in this field, UNSCEAR.*

The 1994 report of the United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR) provides a full picture of the biological effects of low doses of ionizing radiation. The 272-page report specifically addresses epidemiological studies of radiation carcinogenesis and adaptive responses to radiation in cells and organisms.

The report is designed to supplement the more extensive 928-page report that UNSCEAR presented to the UN in 1993. That report addressed global levels of radiation as well as major issues of radiation effects, including the mechanisms of radiation oncogenesis; the influence of level of dose and dose rate on stochastic effects of radiation; hereditary effects of radiation; radiation effects on the developing human brain; and late deterministic effects in children.

Together, these two reports provide an impressive account of current knowledge on the biological effects of ionizing radiation. This article summarizes the highlights of UNSCEAR's assessment of the effects of low doses of ionizing radiation in the context of available radiobiological evidence.

Radiobiological effects: The current understanding

Since the beginning of the 20th century, it has been known that high doses of ionizing radiation produce clinically detectable harm in an exposed individual that can be serious enough to be fatal. Some decades ago, it became clear that low radiation doses also could induce serious health effects, although of low incidence and only detectable through sophisticated epidemiological studies of large populations. Because of the work of UNSCEAR, these effects are now better and more widely understood and better quantified.

Effects at the cellular level: DNA damage and repair mechanisms. The biological effects of radiation derive from the damage it causes to the chemical structure of the cell. For low radiation doses, damage to the *deoxyribonucleic acid (DNA)* in the cell's nucleus is of concern. The damage is expressed as *DNA mutation* occurring in genes in chromosomes of *stem cells,* which can alter the information that passes from a cell to its progeny.

While DNA mutation is subject to efficient repair mechanisms, the repair is not error free. Most damage is repaired, but some damage remains or is badly repaired, and this has consequences for the cell and its progeny.

Evidence of cell adaptation. There is experimental evidence that DNA mutations can be reduced by a small prior conditioning dose of radiation, probably because of stimulation of the repair mechanisms in cells. Such a process of *adaptive response* has been demonstrated in human lymphocytes and in certain mouse cells. The cellular response is transient and there appear to be individual variations. As it is recognized that the effectiveness of DNA repair is not absolute, adaptation is likely to occur together with the processes of DNA mutation and its subsequent effects. The balance between stimulated cellular repair and residual damage is not yet clear.

Dose-response relationship. If DNA mutation depends on radiation's interaction with a single cell, then the frequency of DNA mutation – in cases of no interaction between cells – should follow a linear-quadratic relationship with dose. Furthermore, if it is assumed that, for low radiation doses, mainly single interactions of radiation rather than multitrack effects are dominant, the frequency of cells ,with one or more interactions, and consequently the frequency of DNA mutations, will simply be proportional to dose. Thus, if a fraction of mutations remain unrepaired, the expected number of mutated cells will be proportional to the dose.

Cell killing: deterministic effects. A number of radiation interactions in the cell and some of the unrepaired DNA mutations may lead to the death of the mutated cell, or prevent it from producing progeny. This may occur as a result of the cell's *necrosis* (i.e. its pathological death as a result of irreversible radiation damage) or apoptosis (i.e. a programmed self-destruction of the cell) or because the normal cellular reproduction is hindered. For low radiation doses, cell killing is sparse and therefore of no negative consequence to health owing to redundancy of cellular functions and cellular replacement. For high radiation doses which could kill large numbers of cells in an organ or tissue, the cell-killing effect could be lethal for the tissue and, if vital tissues are involved, for the individual concemed.

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Although killing of individual cells occurs at random, the health effects resulting from the extensive cell killing at high doses are called *"deterministic effects"* because they are predetermined to occur above a threshold level of dose. Deterministic effects, therefore, are not clinically expressed at low radiation doses. Exceptionally, the killing of a few essential cells during organ development *in utero* may result in severe harmful effects clinically expressed in the newly born; these effects are generally referred to as *"effects in embryo"*.

Cell transformation: stochastic effects. Other unrepaired DNA mutations may produce modified but viable stem cells. If the modified cell is a *somatic cell,* it can be the initiator of a long and complex process that may result in severe " somatic health effects", such as cancer. Alternatively, if the cell is a *germ cell,* the mutation could be expressed as *hereditary health effects* in the progeny of the exposed person. These health effects, both somatic and hereditary, deriving from a cell modification are called *"stochastic effects"* because their expression is of an aleatory, random nature.

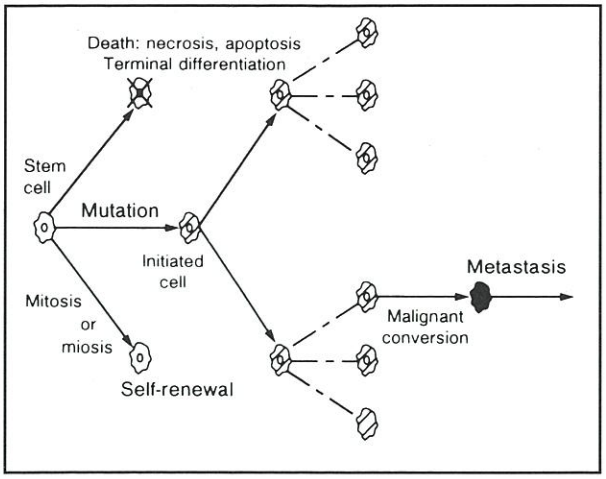
Carcinogenesis

A most important stochastic effect of irradiation is *carcinogenesis.* It is believed to be a multi-stage process and is usually divided, albeit imprecisely, into three phases: cancer *initiation,* tumour *promotion,* and malignant *progression.* It is presumed that radiation is important as an *initiator* rather than as a *promoter* or *progressor.* For low radiation doses, therefore, as the likelihood of initiating mutations is proportional to dose, the likelihood of carcinogenesis should also be proportional to dose.

Immune response and cell surveillance mechanisms. It is argued that immune response may not play a major role in moderating human radiation carcinogenesis. However, specialized immune functions in certain organs and the existence of non-immunogenic cell surveillance mechanisms suggest that a proportion of early pre-neoplastic cells may be eliminated before they become established. Other mechanisms defending against tumour induction and development include the already mentioned DNA repair, apoptosis, terminal differentiation and phenotypic suppression. Altogether, these mechanisms will reduce the probability that a specifically damaged target cell will progress to frank malignancy; to estimate this probability, however, is extremely difficult.

Adaptive response in organisms. Evidence of organic adaptive response to radiation exposure in laboratory mammals has been reported in the literature. However, because of the lack of conclusive evidence, UNSCEAR remains doubtful whether adaptation also occurs at the cellular system level and whether the immune system plays any role in the process.

Epidemiological evidence of carcinogenesis. Although it is not yet possible to determine clinically whether a specific malignancy was caused by radiation, radiation-induced tumours and leukaemia have been detected and statistically quantified by epidemiological studies of populations exposed to relatively high radiation doses. From initiation until the clinical expression of the cancer, a period of time – termed the latency period – elapses. The duration of the latency period varies with the type of cancer from a few years in the case of leukaemia to decades in the case of solid tumours. The action of radiation is only one of many processes influencing the development of malignancies and, therefore, the age at which a radiation-induced malignancy is expressed has been found to be no different from the age for malignancies arising spontaneously.



Multistage process of carcinogenesis

Epidemiological studies of a number of populations exposed to generally high-dose and high-dose-rate radiation – including the survivors of the atomic bombing of Hiroshima and Nagasaki in Japan and patients exposed in therapeutic medical procedures—have provided unequivocal association between radiation dose and carcinogenesis.

The most comprehensive source of primary epidemiological information is the Japanese survivors' "life span study". This has demonstrated a positive correlation between the radiation dose incurred and a subsequent increase in the incidence of, and mortality due to, tumours of the lung, stomach, colon, liver, breast, ovary, and bladder, and also of several forms of leukaemia but not for lymphoma or multiple myeloma. Of the 86 300 or so individuals in the "life span study" cohort, there were 6900 deaths due to solid tumours during 1950-1987, but only approximately 300 of these cancer deaths can be attributed to radiation exposure. The epidemiological data for leukaemia incidence in this same period indicate statistically that 75 cases out of a total of 230 leukaemia deaths can be attributed to radiation exposure. The incidence data also provide evidence of excess for thyroid and non-melanoma skin cancers. The study provides little or no evidence of radiation induction for cancers of the rectum, cervix, gall bladder, larynx, prostate, uterine cervix, uterine corpus, pancreas, kidney, renal pelvis, or testes, or for chronic lymphocytic leukaemia and Hodgkin's disease.

Epidemiological studies on the effects of low-dose-rate exposure undertaken for occupational

exposures have shown conflicting evidence. While a number of occupational studies have reported a significant excess risk of leukaemia in workers exposed to radiation – which is broadly in agreement with the estimates derived from high-dose-rate studies – other studies have failed to demonstrate any positive correlation. Studies of lung cancer in miners occupationally exposed to radon, however, have been able to provide a consistently positive correlation between excess cancer incidence and radiation dose.

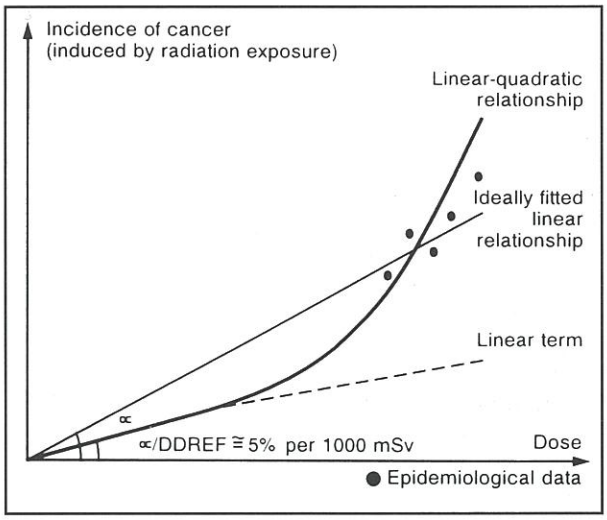
Many environmental exposure studies have been carried out, notably on the incidence of leukaemia in populations living near nuclear installations. Although a few such studies were initially reported to have provided positive correlations between clusters of leukaemia cases and the proximity of nuclear installations, further evidence indicates that it is unlikely that such clusters can be attributed to radiation exposure. A particular exception is a study on people exposed to high level discharges of radioactive materials into the Techa River in the former USSR, among whom leukaemia was found to be in excess. Comparisons of cancer incidence in areas of high and low levels of exposure to natural background radiation have not produced any statistically significant associations.

Inconclusive epidemiological evidence of adaptive response. The human epidemiological studies on adaptation have been of lower statistical power. Therefore, they do not provide evidence of an adaptive response expressed as a decrease in the prevalence of spontaneously occurring human cancers. Moreover, the extensive animal experiments and limited human data provide no conclusive evidence to support the view that the adaptive response in cells either decreases or increases risks of cancer in humans owing to the effects of radiation at low doses.

Models for carcinogenesis. Risk assessments of carcinogenesis are carried out by extrapolation from the limited epidemiological data available, taking account of theoretical assumptions from plausible radiobiological models. For instance, in order to obtain the full life-time risk in an exposed population, it is necessary to project the frequency of induction of excess cancers noted during the period of observation over the entire lifetime of the population. This is now done through a *"multiplicative" model* (rather than through a simple *"additive" model),* which assumes that the rate of induced cancers will increase with age, in proportion to the spontaneous cancer rate (which also increases with age).

Three multiplicative projections are used by UNSCEAR: one assumes that the excess relative rate remains constant throughout life, the others that it will decrease some time after the exposure (the risk of exposure induced death is higher with the constant model while the years lost per induced case can be higher with the other models).

On the other hand, the lack of epidemiological data on the induction of cancer and leukaemia at low doses means that incidence data at high doses must be used for risk estimates. A reduction factor should be applied to the risk deduced from a theoretical linear (non-threshold) fit to the high-dose and high-dose-rate epidemiological data. A reduction factor of about two, which is estimated with considerable uncertainty on the basis of theoretical assumptions and some epidemiological data, is used by UNSCEAR in its risk assessments.



Dose-response relationship.

Hereditary effects

Any unrepaired DNA mutations in germinal cells that are non-lethal for the cell could in principle be transmitted to subsequent generations and become manifest as *hereditary disorders* in the descendants of the exposed individual. Epidemiological studies have not, with a statistically significant degree of confidence, detected hereditary effects of radiation in humans. However, on the basis of genetic experimentation with a wide range of organisms and cellular studies, and taking account of the statistical limitations of the negative human findings, it is conservatively assumed that there can indeed be induction of hereditary effects in humans following radiation exposure. The potential hereditary effects may be the result of:

- dominant mutation (i.e. a mutation in the *dominant allele of a gene,* which can be inherited from only one parent and which leads to disorders in the first generation and can be passed unexpressed through several generations);
- recessive mutation (i.e. a mutation in the *recessive allele,* which can only be inherited from both parents – otherwise, the dominant allele would prevail – and which produces little effect in the first few generations but may accumulate in the population's gene pool, i.e. in the whole of the genes that are present in a population; and
- potentially, *multifactorial disorders* due to mutations resulting from the interaction of several genetic and environmental factors.

The process of generation of hereditary disorders from radiation is less well understood than that of carcinogenesis but the assumptions made are similar: stochastic single cell origin of the disorder with any

radiation interaction is fully capable of being an initiator. Therefore, the response at low radiation doses is also presumed to be linear with dose, with no dose threshold.

Models for hereditary disorders. In view of the lack of direct epidemiological evidence, incidences of radiation induced hereditary effects in humans are estimated through two indirect methods which use data from animal experiments. The *doubling dose (or relative mutation) method* provides the estimate in terms of the additional number of cases of hereditary disease attributed to radiation, using the natural prevalence (of such a disease) as a reference frame. It aims at expressing the likelihood of a hereditary disease being induced by radiation in relation to its natural general occurrence in the population. (Thus, the *doubling dose* is the dose expected to produce as many mutations as those that occur spontaneously in a generation and it is obtained by dividing the spontaneous mutation rate in a locus – or position – of a relevant gene in a chromosome by the expected rate of induction of mutations per unit dose.) The *direct (or absolute mutation) method* directly assesses the expected incidence of hereditary diseases by combining the number of genes at which mutations can occur with the expected number of mutations per unit dose and the dose itself. It is therefore aimed at expressing the likelihood of hereditary diseases absolutely, in terms of the expected increase in the prevalence of the disease. The estimates of risk do not usually include the many hereditary diseases and disorders of complex, multifactorial aetiology, in view of the fact that any effect of radiation upon the incidence of multifactorial disorders should be only slight and is highly speculative.

Effects on the embryo

Effects of radiation *in utero* are generally referred to as effects on the embryo. They can occur at all stages of embryonic development, from zygote to foetus and may include lethal effects, malformations, mental retardation and cancer induction. The first three may be the possible outcome of deterministic effects during embryonic development, particularly at the period of formation of organs.

Evidence of effects on brain growth and development has emerged after observations of severe mental retardation in some children exposed *in utero* at Hiroshima and Nagasaki. The effects from high-dose, high-dose-rate exposure *in utero,* particularly linked to the period between 8 and 15 weeks after conception, seem to indicate a downward shift in the intelligence quotient (IQ) distribution. For low radiation doses, this potential effect on the embryo is undetectable in the newborn.

Studies of *in utero* exposures have given conflicting evidence of carcinogenesis in the child, from relatively high risk to essentially small undetectable risk, including (possibly) none at all. There is no biological reason to assume that the embryo is resistant to carcinogenesis but on the basis of current data such effects cannot be quantified with any certainty.

Highlights of UNSCEAR's conclusions

Taking account of the available radiobiological and radioepidemiological information, UNSCEAR has made a number of quantitative estimates in relation to health effects of low radiation doses. As a result, the scientific body continues to consider that radiation is a weak carcinogen and an even weaker potential cause of hereditary diseases. A summary of UNSCEAR's quantitative estimates follows:

- **Epidemiological Estimates:**

Lifetime mortality:

- 1.1% after exposure of 1000 mSv for leukaemia and 10.9% for solid tumours (12% in total). For reference, in UNSCEAR's 1988 report, the corresponding data was 1.0% for leukaemia and 9.7% for solid tumours.
- linear between 4000 mSv and 200 mSv (little evidence at lower dose).

- **Radiobiological Estimates:**

For low (chronic) radiation doses of around 1 mSv per year:

- *probability of an excess malignancy:* 10^{-4} per year
- *lifetime probability:* 0.5%
- *proportion of fatal cancer in the population that may be attributed to radiation:* approximately 1 in 40.

The above estimates are based on the follow ing assumptions and inferences:

Assumptions:

- *cells in the human body:* 10^{14} cells per individual
- *target stem cells:* 10^{10} to 10^{11} cells per individual
- *initiating event:* single gene mutations in one of around ten possible genes
- *induced mutation rate (per cell):* 10^{-5} per 1000 mSv
- *excess probability of malignancy:* approximately 10%; and
- *interactions per cell:* 1000 per 1000 mSv.

Inferences:

- *excess malignancy:* 1 per 10^{11} to 10^{12} target cells receiving 1000 mSv;
- *rate of target gene deactivation:* 10^{-4} per cell per mSv; and
- *probability that a single track will give rise to an excess malignancy:* 10^{-14} to 10^{-15}.

- **Risk Estimates:**

Risk of malignancies:

- *lifetime probability of radiation induced fatal cancers:*

  5% per 1000 mSv in a nominal population of all ages; and

  4% per 1000 mSv in a working population.

Risk of hereditary effects:
(via doubling dose method)

- ❑ *probability of hereditary radiation effects for all generations:*
  1.2% per 1000 mSv (or 1.2% per generation for a continued exposure of 1000 mSv per generation)
- ❑ *probability of hereditary effects in the first two generations:*
  0.3% per 1000 mSv (via the direct method)
- ❑ *probability of hereditary effects (clinically important disorders) in the first generation:*
  0.2% and 4% per 1000 mSv.

Risk of effects on embryo:
(for those exposed *in utero* in the period between 8 and 15 weeks after conception)

- ❑ *downward shift of IQ distribution:*
  30 IQ points for 1000 mSv
- ❑ *dose required to shift from normal IQ to severely mentally retarded:*
  1000 mSv or more
- ❑ *dose required to shift from low IQ to severely mentally retarded:*
  a few hundred mSv.

Taking UNSCEAR's estimates together and adding to them an estimated detriment from non-fatal cancers, the International Commission on Radiological Protection (ICRP) has recommended the use – for radiation protection purposes – of total nominal risks from stochastic effects of radiation of:

- 0.0073% per mSv for the whole population; and
- 0.0056% per mSv for all adult workers.

These have been the nominal risk factors used in developing the new International Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources.

Outlook

Thanks to the work of UNSCEAR, the biological effects of ionizing radiation are better known than those of many other chemical and physical agents affecting human beings and the environment. However, there are still many unanswered questions in radiobiology, in particular in relation to the effects of low radiation doses.

One problem is the lack of empirical evidence. It should be emphasized that at low dose levels, epidemiological studies presently have only a restricted capability to detect and quantify statistically significant stochastic radiation effects – both somatic and hereditary. As a result, unequivocal direct observational evidence of the effects of low level radiation does not exist and will probably not be obtainable for a long time.

Obtaining unequivocal evidence would require sound epidemiological studies, able to associate an increased incidence of specific health effects with radiation exposure. Such studies would have to overcome inherent statistical and demographical limitations and moreover should include correct case ascertainment, appropriate comparison groups, sufficient follow-up, control of confounding factors and well-characterized dosimetry. It is not now feasible to obtain such evidence for the effects of low radiation doses and therefore a continuing lack of direct evidence on such health effects is to be expected.

Because of these limitations, radiation risk estimates have to rely on an idealized radiobiological model, intended to provide the basis for interpreting the available epidemiological results for high radiation doses. Although the model reflects sound understanding so far, it is rather simple, perhaps even simplistic, and it is still evolving.

Scientific developments are taking place that will extend knowledge of the biological effects of radiation and may necessitate changing the model. Research in molecular biology, for instance, may provide new information on the mechanisms of cancer induction. The mechanisms of adaptive response and the role of radiation exposure in the initiation, promotion, and progression of cancer will be better understood. The coming years might change our view of the health effects of low radiation doses.

Notwithstanding the rapid progress in relevant scientific branches, UNSCEAR has not yet found it necessary to make any major revision to its perception of the biological effects of radiation and the consequent risk estimates. Nearly a quarter of the human population incurs fatal malignancies but, as UNSCEAR indicates, only " about 4% of deaths due to cancer can be attributed to ionizing radiation, most of which comes from natural sources that are not susceptible to control by man".

Call for 1996 Nominations

Fellows of the Canadian Nuclear Society

CNS members who have been designated "Fellows of the Canadian Nuclear Society" belong to a membership category established by the Society in 1993 to denote outstanding merit. The criteria for admission to this membership category include "major and sustained contributions to the sciences and/or professions that relate to the advancement of nuclear technology in Canada." Demonstrated maturity of judgement and breadth of experience, as well as outstanding technical capability, service to the Society, and current CNS membership of at least five years standing, are also requirements for admission.

The newly admitted Fellows are presented with special membership certificates on a suitable occasion at the time of the CNS Annual General Meeting. In the tradition of honorary membership categories of learned societies, CNS Fellows are entitled to add the letters "F.C.N.S." to letters denoting degrees and professional certifications following their names. The maximum number of CNS Fellows at any one time is limited to not more than five per cent of the total membership.

All CNS Branches and Technical Divisions are encouraged to forward confidential nomination statements, signed by three members, to the Chairperson of the CNS Honours and Awards Committee. Alternatively, any three CNS members, not necessarily of the same Branch or Division, may together forward a nomination. The nomination statement should include a focused rationale for the nomination, supported by information on the candidate's:

(i) formal education or equivalent,
(ii) work history, professional achievements, publications and patents,
(iii) experience, demonstrated maturity of judgement and contribution to Nuclear Science and Technology, and
(iv) past services to the CNS.

The Honours and Awards Committee will consider the above criteria with weights of 20%, 20%, 25% and 35%, respectively.

The following CNS members are Fellows of the Canadian Nuclear Society:

George R. Howey	1992
John S. Hewitt	1992
Phillip Ross-Ross	1992
John S. Foster	1993
Terrance E. Rummery	1993
Kenneth H. Talbot	1993
Alan Wyatt	1993
Fred Boyd	1994
Stan Hatcher	1994
Daniel Rozon	1994
Michel Ross	1995
Bob Jervis	1995
Dave Torgerson	1995

CNS Innovative Achievement Award

The Innovative Achievement Award was established by the CNS in 1991. Recipients of the award are specially recognized for

"significant innovative achievement or implementation of new concepts in the nuclear field in Canada."

The award trophy, on which all recipients' names are inscribed, is in the form of an original sculpture showing three figures supporting the Society's logo. Each recipient retains a miniature replica of one figure from the sculpture, as well as a commemorative certificate presented at the Annual Conference of the CNS.

Members of the Society are strongly encouraged to nominate individuals who have made key contributions to a specific innovation. Such contributions should have been to the conceptual, design, development or implementation phase of the innovation, or to a combination of these phases.

Nomination letters should be signed by three persons and accompanied by:

(i) a short biography,
(ii) a description of the particular innovative achievement for which the award would be made, and
(iii) a well focused rationale supporting the nomination,

Previous recipients of the CNS Innovative Achievement Award:

William G. Morison	1991
Wing F. Tao	1991
Andrew J. Stirling	1992
Dé C. Groeneveld	1993
Tom Holden	1994

CNS Team Achievement Award

The John S. Hewitt Team Achievement Award was established by the CNS in 1994. Recipients of the award are specially recognized for

"outstanding team achievements in the introduction or implementation of new concepts or the attainment of difficult goals in the nuclear field in Canada."

The award is in the form of one or more engraved plaques or certificates presented to the members of the team presented at the Annual Conference of the CNS.

Members of the Society are strongly encouraged to nominate teams of generally not more than five persons who have made key contributions to the introduction or implementation of new concepts or the attainment of difficult goals in the nuclear field in Canada. Such contributions should have been to the conceptual, design, development or implementation phase leading to the achievement, or to a combination of these phases.

Nomination letters should be signed by three persons and accompanied by:

(i) a short biography of each team member
(ii) a description of the particular achievement for which an award would be made, and
(iii) a well focused rationale supporting the nomination.

The 1995 recipients were Don McLean, Bill Morgan, Mitch Ohta for the development and demonstration of dry spent fuel storage.

Please send your nominations in confidence, before April 15, 1996 to:

The Secretary
CNS Honours and Awards Committee
144 Front Street West, Suite 725
Toronto, Ontario M5J 2L7

CANDU Maintenance Conference

Reflecting, perhaps, the state of the nuclear power industry in Canada, the **3rd International Conference on CANDU Maintenance** held in Toronto, November 19-21, 1995 drew an overflowing attendance. Well over 300 participated in the event which had 74 papers presented in five parallel sessions in addition to the invited ones at the opening and closing plenary sessions and four "open forum" sessions.

Most of the registrants were from Ontario Hydro and Atomic Energy of Canada Limited but there was a good representation from Hydro Quebec and various companies. Many of the last group were associated with the excellent exhibition that ran concurrently with the conference. The New Brunswick Power contingent withdrew at the last moment because of problems then existing with the Point Lepreau station.

In his opening remarks Ontario Hydro Nuclear General Manger **Ron Field** set a tone and direction for much of the discussion.

Maintenance may not be as glamorous as new construction, Field commented, but it is "absolutely critical to the future of our plants and organizations". Acknowledging that Ontario Hydro had not paid enough attention to maintenance in the past he emphasized the determination to improve. Experience in the USA showed, he said, that low-cost producers were also leaders in safety and reliability.

He stated three objectives for Ontario Hydro Nuclear:

- maintain the highest standards of nuclear and employee safety;
- maintain high capacity factors - on the order of 80 per cent life=-time;
- maintain lower total costs than major alternatives.

All require improved maintenance.

While technology is important, he said, it is essential to enhance maintenance processes, organizations and capabilities.

Processes can be improved by: implementing preventative and predictive maintenance programs; establishing and maintaining safe working conditions; getting the right resources; using the best processes; providing post-job testing.

Maintenance organizations should be improved so that: roles and responsibilities are clear; standards are understood; supervisors and workers function together as a team; managers and supervisors know what is needed in the field.

The capabilities maintenance people must have include: the skills and knowledge necessary; knowledge of procedures; and the willingness to check their own work and do best job possible.

Ron closed with a whimsical plea, "All I ask of our maintenance people is that they make my job a little like the famous Maytag repair man" [in the advertisements]. "A little boredom may be just what is needed by an organization that has had more than its share of excitement in recent years."

Three invited plenary speakers opened the conference: Ken Hedges from AECL, Ted Dunstan of the AECB, and Bob Strickert of Darlington NGS. Bill Pilkington, station manager of Point Lepreau GS had been slated to speak but was reluctant to leave the station.

Ken Hedges outlined the many improvements being incorporated into the CANDU 9 design to improve its maintainability. Included in the approach are: standardization of components, reduction of the number of components, simplification of systems; designing equipment to minimize maintenance requirements; application of human factors engineering; incorporation of operating experience. Some results of this work are applicable to operating stations, he claimed, such as configuration management, improved elastomerics, information technology to assist with major repairs; application of robotics and remote tooling; automation of safety system testing.

Ted Dunstan spoke on regulatory requirements for maintenance of ageing reactors. (His paper is reprinted in this issue of the *CNS Bulletin*.)

Bob Stickert entitled his address as "New perspectives about maintenance in the future". He spoke of "nuclear excellence" with emphasis on human involvement and culture. Teamwork is essential, he stated, pointing to nuclear plants in Finland as examples.

As well as all the papers in the conference there were speakers at both luncheons and at the conference dinner.

In his after dinner speech, **Robert Nixon**, chairman of AECL, noted that, with no new construction, maintenance of existing plants was very important. He observed that there were many questions circulating about the nuclear industry in Canada, such as: will Ontario Hydro buy AECL ? Will AECL buy Ontario Hydro Nuclear ? Will Walmart buy them both ? While not answering the questions he stated his belief that the whole nuclear community must come together [better than in the recent past].

Peter Schurmann, of Siemens Electric, presented a fascinating film in place of an after-lunch talk. Entitled "Concierto Evolucion" it had been made for Siemens' pavilion at Expo '92 in Seville. Through a

Ken Talbot gives the wrap-up talk at the CNS CANDU Maintenance Conference in Toronto, November 1995.

combination of music and artistic photography it expressed the thought: *Our technology-driven civilization runs the risk of destroying itself unless technology is guided by a consecrated effort to reestablish and maintain a balance between the needs of humanity, nature and technology.*

The other luncheon speaker was **Bob Long**, vice-president of GPU Nuclear, operators of Oyster Creek and TMI-1 nuclear plants, who spoke on "Strategic Planning and Continuous Improvement". Much of his talk dealt with the organization of GPU into six business units which all had the same "strategic focus" : maximizing effectiveness and efficiency; reorienting the culture; positioning for competition; growing the business. His comments on teamwork, leadership training, productivity improvement, process re-engineering and small group problem solving, seemed to strike a cord with the many Ontario Hydro Nuclear staff present.

Finally, as a closing act, **Ken Talbot**, director of Bruce "A" NGS, spoke, in his typically upbeat style, on "Managing Ageing Plants". Bruce "A" has already lost one unit due to poor maintenance in the past, he noted, but a "life-cycle management program" now in place will keep the others running well into the future. In fact, he said, they were looking at restoring the shut-down unit 2. He noted a number of achievements over the three years (since the last Maintenance Conference) such as eliminating almost all call-ups, reducing forced outage rate by a factor of three, and SLARing more than 500 channels.

The 74 papers presented covered a wide range of topics related to the maintenance of CANDU plants. Some indication of the scope can be gained by the titles of the sessions, which included: Predictive Maintenance; Reliability Improvements; Steam Generator Monitoring; Tools and Instrumentation; Improving Valve Performance; Fuel Channel Inspection and Maintenance; Steam Generator Cleaning; Decontamination and Rediation Protection; Remote Tooling and Robotics. Copies of the Conference Proceedings, which includes full papers, are available from the CNS office.

The conference was very well organized. Chairman Mark Brown, technical program co-chairs Tim Andreef and Martin Reid, and all the others of the organizing committee can be justifiably proud of the results of their efforts. The exhibition was well displayed with sufficient room for the coffee breaks and the receptions held both on the opening Sunday evening and Monday. The dinner and luncheons were included in the conference fee (unlike conferences in the USA and Europe) and were very good. Finally, the proceedings were available at the conference.

The only negative aspect was the occasional crowding, especially in some of the "open forum" sessions. But that only reflected the popularity of the topic and of the conference. Recognizing that fact, organization is already underway towards a fourth CANDU Maintenance Conference for the fall of 1997.

Bruce Unit 2 Rehabilitation

Ed. Note: *In his talk to the 3rd CANDU Maintenance Conference in November 1995, Bruce "A" director, Ken Talbot, commented that they were exploring ways of rehabilitating the shut-down Unit 2. The following is extracted from the January 1996 issue of The Nuclear Business Review publishing by Ontario Hydro Nuclear.*

Bruce "A" Nuclear Division has begun inviting expressions of interest from nuclear architect-engineers, nuclear manufacturers, contractors and other organizations to participate in the proposed restoration of Bruce Unit 2.

The aim is to return Bruce Unit 2 to service and to operate it for the period 2000 to 2018 and beyond.

Early in December 1995 a Request for Expression of Interest was issued and was followed by a meeting with potentially interested organizations later that month. Interested organizations have been requested to submit formal expressions of interest. These will be evaluated before any decision is made to move to the next stage.

The objectives of the program include the following:

- to return Bruce Unit 2 to power with maximum attention to safety, reliability, schedule and cost, resulting in a unit which will produce energy safely at an average cost of less than 3 cents / kWh (1995 $ Cdn);
- to reduce or share financial risk on individual projects or the complete program;
- to be consistent with commercial orientation by having more flexible capital structures, less dependence on in-house capability;
- to form alliances with strategic partners, thereby gaining access to new markets or developing new products;
- to obtain synergy from strategic partners and thereby reduce the total project or program cost.

There are three components to the proposed restoration project:

- removal and replacement of the 480 fuel channels
- replacement of all eight boilers;
- a variety of small individual projects.

Maintenance of Ageing CANDU Reactors a Regulatory Perspective

Ted Dunstan

Ed. Note: *Ted Dunstan, the Atomic Energy Control Board's Senior Project Officer for the Bruce "A" and "B" nuclear power stations of Ontario Hydro, was one of the invited Keynote Speakers at the 3rd CNS CANDU Maintenance Conference held in Toronto in November 1995. The following article is a slightly edited version of his notes for that presentation.*

The subject of this paper is, **"requirements for maintenance of ageing reactors from the perspective of a regulator"**, with a focus on the particular theme of; **"continuing safety assurance"**.

A major role of maintenance is to ensure the continuing reliability and effectiveness of safety related systems and equipment.

Continuing safety assurance is an issue the Atomic Energy Control Board has been wrestling with for some time.

From my perspective, much remains to be done before the AECB can be confident that Canadian nuclear plants have the necessary programs in place to achieve continuing safety assurance.

To introduce the topic, it would be appropriate to say a few words about the AECB's position with respect to the situation at the Pickering NGS. Why did we blow the whistle last August and, what are we doing about it?

Pickering

Why did we blow the whistle?

AECB staff reached the conclusion in August, that safety performance at Pickering had deteriorated to the extent that immediate corrective action was essential to prevent the level of risk to the public becoming unacceptable.

A number of indicators led us to this conclusion, including:

- an increasing frequency of serious events, many of which involved procedural violations;
- evidence of a lack of management commitment to safety, and;
- a lack of understanding of safety principles amongst plant workers.

The reporting of several of the serious events provided some of the evidence of a lack of commitment to safety. Instead of acknowledging the safety significance and seriousness of the event, the reports focused on explaining why the event had little or no impact on safety.

What are we doing about the situation?

Our senior project officer at Pickering meets with the station director every week to receive an update on the corrective actions underway at the station and to discuss them with him.

In mid October, we set up a four person task group of AECB specialist staff to monitor and evaluate the corrective actions Ontario Hydro was taking to improve operational safety performance at the Pickering NGS. Each person in the group will have spent approximately 30 per cent of their time on the project until completion. Their findings will be an important consideration in the staff recommendation for renewal of the Operating Licence in the fall of 1996.

Our final decision on the acceptability of continued operation of the Pickering units will be based on actual measured results of relevant safety parameters.

Continuing Safety Assurance - Background

Now, to my main topic, continuing safety assurance. I will begin with some background information on recent changes in the focus of licensing activities at the AECB.

Not long ago the AECB's major efforts in reactor regulation were spent on the licensing of new plants. Thirteen of the 21 operating power reactors in Canada received their first operating licence in the past twelve years. Now, as in many other countries, our emphasis in regulation has shifted to the assurance of continuing safety of ageing reactors. Up to now, we have made this change in our regulatory activities, without any change in our regulations or regulatory policy.

The conditions governing operation of Canadian nuclear plants are defined in the operating licences. Only one Clause in the licence addresses the issue of continuing safety assurance. This is Clause AA 11, which states that,

> *"maintenance shall be of such a standard that, in the opinion of the AECB, the reliability and effectiveness of plant equipment and systems as claimed in the safety report ... are assured".*

This is one of the most important licence requirements for our review of operational safety. However, in the absence of regulatory standards or acceptance criteria, we find it difficult to assess compliance.

In a separate paper to this conference, my colleague, Imtiaz Malek, outlines the AECB's current approach to the assessment of maintenance. It describes some of the difficulties we are experiencing in carrying out a review to determine compliance with Clause AA 11.

In the early years of plant operation, it is assumed that its equipment and systems will perform as designed. Also, the safety margins built into the plant's design, provide some protection against operational errors and poor maintenance. However, as the plant grows older, these safety margins will shrink due to the effects of ageing and the impact of operating and maintenance practices on safety, will increase. It follows, therefore, that for the requirements of Clause AA 11 to continue to be met, ageing of plant equipment must be well managed .

Management of NPP Ageing

Responding to the growing realization that plant ageing was a major emerging safety issue The International Atomic Energy Agency (IAEA) began studying the safety aspects of ageing about ten years ago. In 1989, they launched a structured program of investigation. The program integrates information on the safety aspects of ageing, from the IAEA member states, into a common knowledge base, which is then used to develop safety guides. Several such guides on ageing have now been issued and are available. Ontario Hydro and AECB staff have actively participated in the IAEA's work.

There are two types of ageing to consider; "physical" ageing and "non-physical" ageing.

"Physical" ageing is the time-dependent degradation of materials due to their service (or storage) conditions.

(Creep growth and hydrogen embrittlement of pressure tubes; stress corrosion, fretting wear, and fatigue cracking of boiler tubes, and erosion of wet steam piping are examples of physical ageing degradation.)

"Non-physical" ageing is the process of becoming obsolete, ie, "out of date" in comparison to today's standards of safety and technology.

(The PDP 8Efuel handling computers at the Bruce GS's and the lack of seismic qualification at Bruce A and Pickering A are examples of non-physical ageing).

I'll deal with physical ageing first.

In the 1970's and early 1980's, commercial sized CANDU plants were young and age-related equipment failures were rare (or not recognised) . At that time, most people believed, that the programs already well established, such as, preventative maintenance and surveillance programs, and safety system testing programs, were sufficient to ensure that ageing did not threaten plant safety.

The pressure tube failures at Pickering in 1984 and Bruce in 1986 indicated that the programs in place were not sufficient to provide such assurance. More recently, the industry has experienced leaking boilers at several plants on numerous occasions and various other component failures, mostly at the older plants, attributable to ageing effects.

Thanks to the major efforts devoted by the industry to improving the understanding of pressure tube and boiler tube degradation processes, and to developing inspection techniques and fitness-for-service criteria, we are reasonably confident that Canadian plants have effective ageing management programs in place for these important safety components.

Also, in recent years many new programs to monitor performance of safety significant components have been initiated such as diagnostics for motor-operated and air-operated valves, vibration monitoring of rotating machinery, surveillance of secondary side piping etc.

However, CANDU plants contain many other safety significant components, such as, valves other than motor-operated and air-operated valves, pumps, heat sink pressure boundaries, instruments, relays, switches, breakers and cables, electronic and computer hardware, etc, as well as consumables and perishables such as, oils, greases and rubber seals. All of these are susceptible to ageing which can result in unacceptable system performance and can invalidate the plant's safety analysis.

About five years ago, the AECB decided it needed to establish a regulatory position on requirements for managing ageing.

In October 1990, we raised a Generic Action Item on all our licensees. Hydro Quebec, New Brunswick Power, and Ontario Hydro were asked to inform us of the means by which they are assured of the continued safe operation of their plant(s) as they age.

This was clearly a tough assignment since it was several years before we received an answer from any of them.

In early 1991, I chaired a small AECB task group who's mandate was to prepare recommendations for a regulatory position on requirements for management of physical ageing. We issued a draft document for internal AECB comment a year later. It was accepted in principle at the time and will be used as a basis for a future regulatory document.

I'll quote some extracts from this draft to illustrate the requirements we envisage for ageing management programs that I want to emphasise.

"Purpose"

> *"The AECB requires assurance that ageing degradation of equipment does not compromise safety as CANDU plants grow older. It therefore requires owners and operators of these facilities to have in place an auditable program, or an integrated process comprising several programs, that provides for effective management of ageing for all plant systems and equipment important to safety."*

We define the set of safety significant structures, systems and components, (ie SSCs) to be included in the program this way;

"All SSC's who's ageing degradation could;

a) increase the probability or consequence of serious process failures

b) render a special safety system less effective or less reliable

c) cause key system parameters such as flows, temperatures, pressure drops, heat transfer rates, etc, to change to the extent that they exceed the limits assumed in the safety analysis"

(Note that these are the set of SSCs referred to in licence Clause AA11.)

The document goes on to describe eight key elements of a program for the management of ageing . (Copies of the draft document are available).

AECB Review of Licensee's Ageing Management Programs

When we reviewed the utilities' responses to our 1990 Generic Action Item we found that they all have many of the elements of an ageing management program planned or in place. For example, we found that, in addition to inspection, surveillance and test programs required by the licence, all have comprehensive preventative maintenance programs, life management programs for P/Ts and B/Ts, operating experience feedback, in-service inspection programs for secondary side piping and, system surveillance activities conducted by system engineers.

We found the approaches to ageing management described by New Brunswick Power and Ontario Hydro are comprehensive and systematic, with well defined objectives. As described, these programs are entirely consistent with some of our expectations of an ageing management program.

Overall, it's our impression that much of the work required to establish effective management of ageing has already been done. What is needed now is a comprehensive review against the safety objectives of the program to identify any shortcomings and then appropriate follow-up action to remove them. For example, none of the utilities programs indicates the following:

1. The scope of application of the program, in terms of the plant SSCs to which it applies.
2. How SSCs important to safety will be identified (in fact, only Ontario Hydro's response says that this must be done!).
3. How the various programs described will be integrated and co-ordinated such that the overall ageing management program objectives are achieved.

We believe the probabilistic safety analyses (PSAs) such as the Risk Assessments for the Ontario Hydro plants, and the safety design matrices (SDMs) for the CANDU 600s, can be very useful for identifying safety significant SSCs. They also allow these components to be ranked according to their safety significance.

The AECB strongly supports the recommendations given in the draft IAEA publication, Safety Series 50, *"Implementation and Review of Management of NPP Ageing Program"*.

This document provides guidance for establishing effective integration and control of programs for management of ageing. It stresses the importance of comprehensiveness and of an integrated and systematic approach to ageing management. It also advocates the formation of an independent group headed by a manager to coordinate the ageing management program, a view which we support, particularly for the multi-unit Ontario Hydro stations.

New AECB regulatory documents:

We have started a program to improve the documentation of our regulatory requirements and guidelines for NPPs. Among the new documents being considered are the following:

- Requirements for maintenance, surveillance and management of ageing (this is the document that will use the draft recommendations I spoke of)
- Reliability requirements for safety related systems of nuclear reactor facilities (this is C-98 that some of you are already familiar with)
- A Backfitting policy
- A policy on Cost benefit considerations in regulatory decision making
- Requirements for periodic safety review
- Requirements for configuration management
- Requirements for environmental qualification
- Requirements for residual heat removal.

There is also a strong move afoot at the AECB to replace the existing regulatory process for nuclear power plants with a risk-based one. This means regulation that is based not only on the traditional deterministic safety criteria, which is essentially what we have now, but also on an assessment of risk. This could expand the application of ALARA in the regulatory process to embrace nuclear safety overall. We would be looking for a risk management process where the goal was to maintain public risk "as low as reasonably achievable" However, this is unlikely to happen before each station has a PSA in which the AECB has confidence.

Non-Physical Ageing

AECB staff believe that non-physical ageing (ie, growing obsolescence) is best addressed through a process of periodic safety review. Such a program would be performed by the licensees on a five, or more likely, ten-year cycle and would entail an assessment of such things as :

- the physical condition of the plant, the safety analyses, equipment qualification, the ageing management program, plant safety performance, use of experience from other plants and of research findings, station procedures, organization and administration, human factors, emergency planning

The purpose of such a review is to determine whether the plant is safe as judged by current safety standards and practices and, whether adequate managed processes are in place to maintain plant safety in the future.

This does NOT imply that all current requirements for safety have to be met.

Concluding Remarks

Finally, I'd like to offer some concluding remarks on where we need to go from here.

- The AECB and the licensees need to take action to provide continuing safety assurance of CANDU plants in the long term.
- The AECB needs to develop and issue new regulatory documents that define operational safety requirements more clearly so that it can assess operational safety performance more effectively.
- The utilities need to define safety objectives for their maintenance programs consistent with Clause AA 11 of the operating licence, and then make the necessary changes and additions to their managed processes to achieve these objectives. (The most important additions needed, in my view, are, the establishment of a clearly defined scope of application, i.e., a definition of safety significant SSCs, and, effective integration/co-ordination of the various programs that contribute to the reliability and effectiveness of safety significant SSCs.)

3rd CANDU Maintenance Conference

Mobile Robotics for CANDU Maintenance*

by M.G. Lipsett and K.H. Rody

ABSTRACT

Although robotics researchers have been promising that robotics would soon be performing tasks in hazardous environments, the reality has yet to live up to the hype. The presently available crop of robots suitable for deployment in industrial situations are remotely operated, requiring skilled users.

This talk describes cases where mobile robots have been used successfully in CANDU stations, discusses the difficulties in using mobile robots for reactor maintenance, and provides near-term goals for achievable improvements in performance and usefulness.

1. INTRODUCTION

The advantage of using a robot for inspection and maintenance is that a robot can gather information and do work in highly hazardous areas. In such areas, and to a lesser extent in inaccessible areas, conventional remote sensors and tooling can not be deployed. information gathered by robots about the hazards can be used to rehearse procedures, which reduces dose during the task. In some cases, simple gripping and actuation tasks can be done by the robot instead of by a human, allowing tasks to be done in inaccessible areas quickly, cheaply, and safely.

Robots for CANDU maintenance fall into two categories: mobile vehicles and portable manipulators. The mobile robot is most useful for delivering sensors to a highly hazardous location to gather information. the portable manipulator is used for jobs with a limited work space where hazards are local.

As well, the fueling machine can be used as a robotic tooling delivery system at the reactor face.

1.1. Mobile Vehicles

Mobile robots with manipulators are in use at Ontario Hydro CANDU stations. All share similar characteristics: they are wheeled or tracked machines with simple manipulator arms. The user drives to a location of interest to survey a scene remotely with video cameras, make a radiation survey, or perform rudimentary manipulation tasks. The robot is either tethered or self-powered and radio-controlled; the machine does not operate under automatic control.

One model has been modified to be carried by crane to a location; most models can ride elevators

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and operate buttons. Some models can climb stairs or crawl in pipes.

Pipe inspection robots are tethered, remotely operated tracked vehicles that crawl through pipes looking for abnormalities with on-board video cameras and lights. These mobile robots are built for small spaces and for moving along pipes with low flow. The Babcock & Wilcox (B & W) ROWER and the Inuktun SEAMOR have been used at Pickering; SEAMOR is a submersible robot suitable for 20-inch pipes; it can also act as a conventional mobile robot when fitted with a small manipulator for object retrieval[1].

A Remotec Andros robot has recently been acquired by Darlington. This robot has articulated tracks for climbing catwalk stairs. Bruce-A and Bruce-B use Pedsco wheeled mobile robots.

The Pedsco at Bruce-B has already done remote visual inspections of equipment in hazardous environments, made radiation surveys, retrieved pieces of failed equipment, and monitored a maintainer's progress on a job without dosing another maintainer.

1.2. Portable Manipulators

Portable manipulators are used mostly in the bowls on the primary side of CANDU steam generators. This is an appropriate workspace because work inside the bowl does involve dose, but equipment can be brought to the boiler easily. Ontario Hydro has been using a Vermatt-Technics Flexivera manipulator with ABB-CE tooling for tube plugging. This portable robot arm is assembled inside the bowl in sections and remotely controlled from containment[2]. Zetec and B&W also make steam generator robots, which through the manway for faster set-up and removal. Such manipulators can be used to deliver other tools for tube inspection and repair. No robotic systems are presently in use on the secondary side of the boilers; water lances (such as those used by B&W) are articulated flexible probes, not robots.

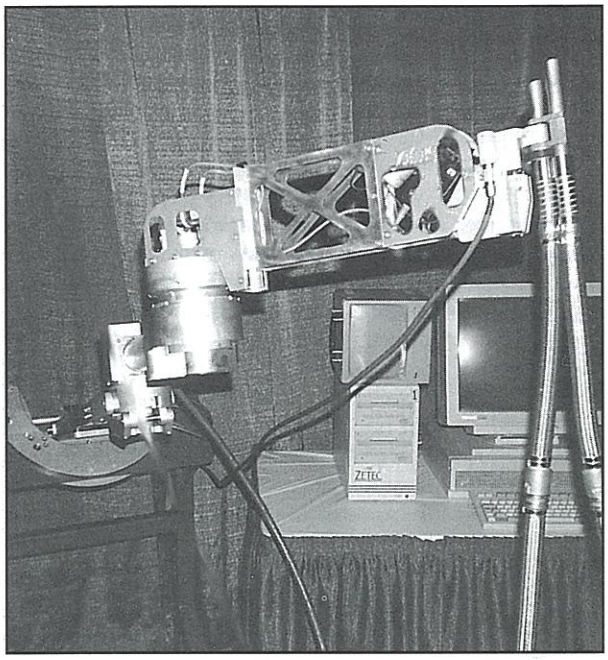
ANDREA (manufactured by B&W) is a non-mobile, hydraulic manipulator for inspection and simple maintenance tasks inside the PNGB-A calandria vault. CALVIN, another manipulator, was developed specifically for calandria vault inspection[1].

1.3. Fueling Machines

The fueling machine (F/M) itself acts as a robotic tool delivery system for pressure tube sampling by wet scraping and molding, CIGAR, SLAR, PIPE, and SLARETTE. This is an excellent example of using modular tools with a common delivery system. The fueling machine is the only permanently mounted robotic system in the CANDU reactor vault. Bruce-B is considered building a Universal Delivery System for delivering inspection tooling.

2. LIMITATIONS

Mobile robots have limited capabilities: the driver has to use video to see where to go; there is no map except in the driver's memory; the arm is not versatile; and power is limited.



One of several robotic devices displayed at the equipment display associated with the CNS CANDU Maintenance Conference in Toronto, November, 1995.

2.1. Getting Around the Vault

The driver of the vehicle has to visualize what the machine is doing with only the feedback from video cameras. This level of sensing is adequate, provided that the driver can navigate to the place of work without collisions.

Robots have not been used for other remote tasks because it is difficult to deploy the machine to some parts of the vault. presently, the Bruce-B robot enters through the transfer chamber or goes into the reactor vault on the fueling machine transport trolley. But interlocks prevent the crane from approaching close enough to the reactor face to engage the lifting bar on the robot to lift it to higher elevations.

Because of the limitations of using fuel handling equipment to get the robot into the vault, alternative strategies for entry into the vault have been proposed, such as going through the airlock. Operational procedures have to be reviewed before robots can be allowed to enter an airlock while the reactor is on-power; one option is to erect a temporary third doorway to maintain an airlock even when one door is open. An additional concern at Bruce-B is that the airlock doors and pressure equalization mechanism are manually operated, and the robot is not capable of opening and closing the airlock by itself. A worker may have to drive the robot through the airlock.

2.2. Autonomous Navigation

Much recent robotics research effort has focused on enabling a mobile robot to navigate by itself[3,4]; but autonomous navigation is not necessary for the type of specialized CANDU maintenance tasks that

mobile robots will be doing in the foreseeable future. It is sufficient that a robot vehicle can be driven by the user without colliding with anything, and that it can backtrack when necessary. The onus is on the driver to keep track of where the machine is at a given time. Users of mobile robots practice to sharpen their orienteering skills as well as their driving technique.

The driver has to communicate over a tether or a radio link. radiation fields have not interfered with radio communication or control in the fueling duct under reactors at power; communication in the vault itself while at-power has not been attempted.

2.3. Manipulation

Once the robot has reached the work site, the task is to make measurements or to manipulate a tool to do work. The manipulator arm is used to move a camera, an instrument, or a tool in a small work space. The arm is joint-controlled, which means that the user has to move the individual joints with joysticks and use video for feedback. This method of open-loop control makes dexterous handling very difficult and tiring. The robot arm can not handle a large payload. There are few sensors or tools that can be changed in the field to do different kinds of tasks.

In cluttered work areas, it would be advantageous for users to have closed-loop control for accurate positioning. Range imaging system can also be used to calibrate a scene[4]. But users do not need telepresence or fancy displays: they need machines that can do a small set of tasks reliably.

2.4. Power Supplies

An untethered robot must either drag an extension cord, or it must carry its power supply on-board, which limits the robot operation time. Recharging stations are not available inside containment. It matters little if the machine is retrievable from the vault immediately after the job, provided that the robot is secured and does not interfere with the operation of the reactor, up to and including the time that the robot can be retrieved.

3. CASE STUDIES

3.1. Fueling Machine Failure Diagnosis

In March 1992 at Bruce Unit 8, the Northeast fueling machine became struck on a channel while attempting to replace a closure plug. The diagnosis of a charge tube drive failure was confirmed only after the Bruce-B mobile robot was sent to investigate[5].

From the East Service Area (ESA), the robot was driven through the transfer chamber and brought to the bottom of the stairs. The robot drove along the fueling duct, controlled by a maintainer in plastics in the ESA operating by radio control with video feedback. The robot had no problems with communications or with negotiating pipes in its path as it drove under Unit 8 while the reactor was a full power. The robot found the charge tobe axial drive shaft in the fueling duct where it had fallen. The robot picked it up with its gripper and carried the shaft back to the ESA.

The robot thus confirmed the fault diagnosis and eliminated the need for a dose-intensive inspection and survey. knowing the exact cause of failure allowed preplanning and rehearsal of the repair. During the actual repair, the robot monitored dose and provided visual feedback so that the maintainer could be coached.

3.2. End Fitting Visual Inspection

A CCD video camera was mounted on a Bruce-B F/M carriage to make a visual inspection of all end fitting sealing faces on the reactor face. The F/M was programmed to pass along all end fittings with an offset to align the camera. Video output was tape recorded for later inspection, which revealed pitting in the bottom segment of many sealing faces.

3.3. Leak Sealing of Shield Tank Wall

The SEAMOR robot was used as a robot submarine for inspection and leak sealing of the PNGS-A shield tank wall. the robot was tethered with an air0line driven motor for brushing an area clean and applying epoxy. the epoxy was mixed outside, so the robot had to apply the coating within twenty minutes. The robot carried its thirty pound payload using foam for neutral buoyancy. This robot was also used for underwater inspection of a trolley in the fuel bay, and in screen houses to examine the extent of zebra mussel infestations.

3.4. Radiation Surveys on Open Channels

During maintenance on open channels, radiation surveys have been made by the Bruce-B robot on a mini-platform on top of the carriage, mapping the beam and doing inspections into the channel. A CCD camera can be used in high fields; although a standard CCD camera has a nominal cumulative dose limit of 20 KR, often a camera will recover its sensitivity. A gamma meter is mounted onto the side of the arm with a separate video camera dedicated to reading that meter.

3.5. Valve Inspection from Inside Pipe

in most cases, inspections inside pipes can be done with video scopes or fiber scopes without having to open the pipe network. But these instruments require and access opening to the area if interest. The submersible SEAMOR robot once traveled on tracks inside a 2-foot line to make an internal visual inspection of a broken valve.

4. ENHANCEMENTS

Rather than redesign a new machine, we propose that commercial mobile robots be modified to improve their performance and usefulness in CANDU stations.

4.1. Modular Tooling and Instrumentation

The arm has to be able to release and end effector and pick up another when it needs a different tool. The robot therefore needs a tool changer for instruments and tools, with a standard mount with positive lock and a connector for power and signal conductors. Examples include tools to collect smears or

collect grab samples, custom grippers, tools for fasteners, leak detectors, and gamma meters.

4.2. Improved Communication Link

The user interface has to be able to read the modular sensors and actuate the modular tools. The communication link has to accommodate the rang of tasks the robot can perform remotely. Existing systems will require upgrades. Using a penetration for radio transmission would improve reception. The radio transmitter must not affect reactor operation.

Electronics can be designed for high radiation fields; of mobile robot vendors, only Remotec specifically offers that option for its controller hardware. The controller architecture should be open for expandability and reconfigurability, but that is not a requirement.

4.3. Improved Power Supplies

Mobile robots can operate over a tether or by radio link with batteries. A recharge adapter would allow an untethered robot to operate longer inside containment. the adapter would be held in an end effector and would plug into a mains receptacle in the vault.

4.4. Modular Improvements to Manipulator Arm and Vehicle Base

Different tasks require different performance abilities, driven by task expectations. Modular subsystems allow the machine to be configured to perform the job at hand. Improved arms will have less backlash, more power, and improved dexterity for maintenance tasks on complex parts in cluttered environments; for inspection, however, no major modifications to the arm are necessary. In all cases, the components must be rugged, corrosion resistant, and washable for decontamination.

5. TARGET APPLICATIONS

5.1. Maintenance Support

Target applications for the improved system include inspection programs (both while on-power and during shutdowns) and testing of environmental conditions in different areas of the reactor while on-power to gather data for environmental qualification.

5.2. On-Line Operating Support

An application for robotics should provide more feed-back into the condition of an area where there is little information available by other means. Inaccessible areas with little or no instrumentation are primary target areas. There are clear benefits to providing an operator with the means to find out the condition of equipment in containment that is not well instrumented. A mobile robot can be driven to a piece of equipment so that condition monitoring could be done on-line using video and audio inspection, or existing vibration and thermographic analysis techniques. This level of support for operations is achievable using existing technology with little additional development.

Using mobile robots for autonomous remote inspection and maintenance tasks remains a near-term dream until manipulators have; more degrees of freedom to be dexterous, joint sensing for closed-loop control, reliable controllers, an accurate ranging system for workspace geometric modeling, a user interface that is easy to use, and an automatic method of avoiding collisions in a cluttered work space. None of these necessary characteristics is available off-the-shelf, but they are all achievable with today's technology. For today's maintenance problems, however, mobile robots should be modified incrementally for reliable teleoperation rather than autonomous operations.

5.3. Fuel Channel Replacement

The most important area for robotics to be used in reactor maintenance is in fuel channel replacement.

To maintain fitness for service of fuel channels economically, channels must be replaced without long outages. The way to do this is to change several channels during each outage, thus maintaining the integrity of the pressure tubes. Single channels can now be replaced in fifteen days, but the time and the dose to workers could be reduced by automating most of the tasks, which keeps workers away from the face and reduces the need for building temporary shielding structures (a major dose task in itself). The existing fueling machine bridge and carriage should be used as the delivery system for robotic tooling for fuel channel replacement and refurbishment of end fittings.

Remotely operated tools comprise three modules that attach to the F/M carriage. The old pressure tube (P/T) is removed by machining the end fitting (E/F) rolled joint (R/J) area with a larger diameter in one E/F to allow for annulus spacer clearance and installation of the new pressure tube. End fittings are not removed, which eliminates the need for bellows welding. The E/F R/J is made using a composite insert and a heavy P/T wall at the opposite end.

Implementation of robotic tooling cna be incorporated into single fuel channel replacement (SFCR) campaigns as the tools become available, so that the system has an early impact on reducing SFCR time and dose. An immediately useful application would be to resurface end fitting sealing faces. In this way, the system can be developed and used promptly, the design remains closely tied to user requirements, and the system can be upgraded as required.

6. CONCLUSION

The near-term goal of modifying mobile robots for use in CANDU maintenance should not be to produce high-performance teleoperation systems. the goal should be to implement a series of incremental improvements. each improvement moves toward higher performance and versatility, but utility and reliability should be added to mobile robots while keeping them available for maintenance tasks. in this way, mobile robots can assist in maintenance in radioactive areas so that it can be done more safely, in less time, and with less radiation exposure to workers.

ACKNOWLEDGEMENTS

The authors wish to thank Andy Tokarz and Kamli Shamoon for their helpful cooperation in preparing this paper.

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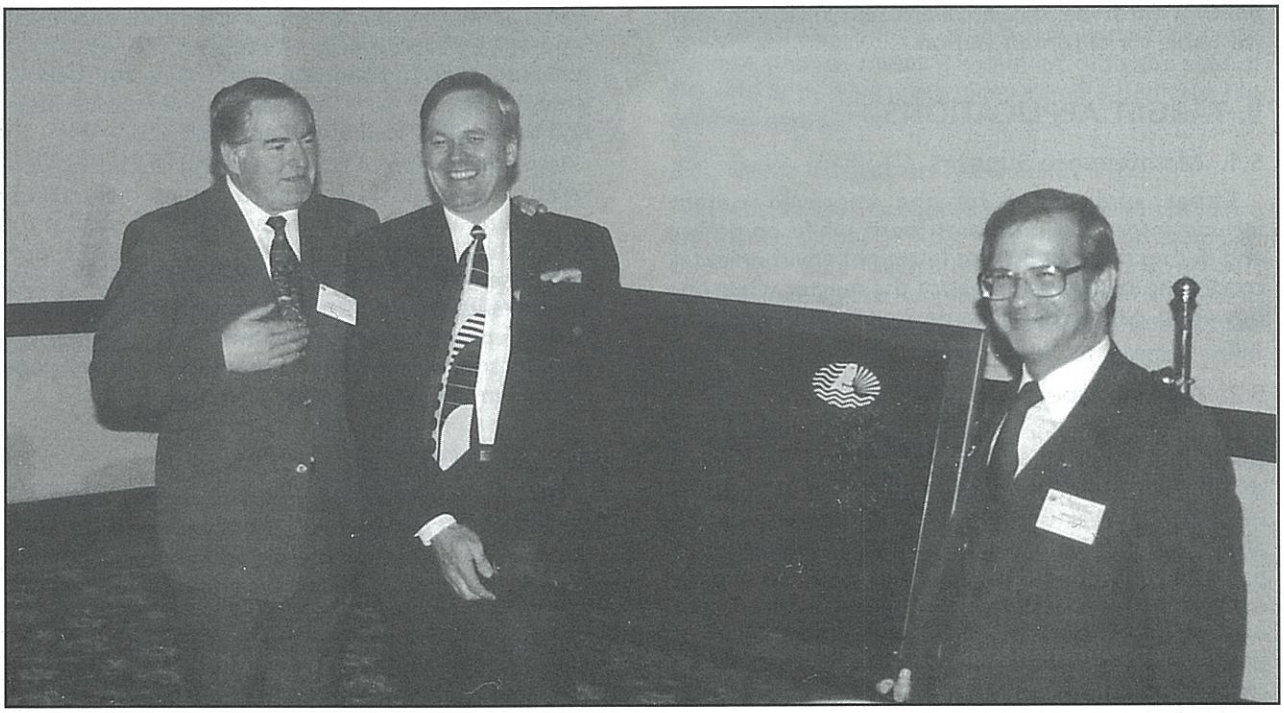


CNA president Jack Richman (L), and CNS president Jerry Cuttler present Pickering NGS director Pierre Charlebois with a plaque to commemorate the 25th anniversary of the start-up of Pickering unit 1, at the CNA/CNS Nuclear Winter Seminar in Ottawa, February 1996.

CNA/CNS

Winter Seminar

— the annual review of the industry

There appeared to be an upbeat mood at the 1996 Nuclear Energy Winter Seminar, despite the lack of new domestic nuclear plants and the impending cuts by the federal government. Most of the 125 or so delegates seemed to agree with AECL president Reid Morden when he spoke optimistically of the prospects for export sales of CANDUs.

The annual event was held as, usual, in Ottawa, on February 5 and 6, with Members of Parliament, Senators and senior bureaucrats invited. Although a dinner was added this year to the reception on the first evening, only a relatively small number of politicians attended. Unfortunately the House was not sitting.

Standing in for Anne McLellan, Minister of Natural Resources, her Deputy Minister, **Jean McCloskey**, welcomed the group and provided a concise overview of nuclear related activities. The conclusions from the program review of AECL will be announced with the budget later this spring but, she warned, "times are tough" and "all must share in the pain". However, she noted, there are good prospects for CANDU sales in Korea and China. Regarding a new [Atomic Energy Control] Act she stated that the Minister was very aware of the need and expected to introduce it soon. Her department is developing a policy for nuclear waste, building on the discussion paper issued last summer. Uranium is the bright spot and with the rich finds in Saskatchewan she commented that Canada was becoming the "Saudi Arabia of uranium". In closing, she referred to the remarks of CNS president, Jerry Cuttler, about the need for better communication with the public.

The only other "official" activity on the first evening was a presentation of a plaque by the Canadian Nuclear Association and the Canadian Nuclear Society to **Pierre Charlebois**, Director of the Pickering NGS, to commemorate the 25th anniversary of the start-up of the first Pickering unit.

The full day of presentations began with introductory remarks by **Murray Stewart**, chairman of the CNA and **Jerry Cuttler**, CNS president, followed by an overview by AECL president **Reid Morden** which he titled *"Challenges in 1996"*. Morden structured his talk on triple "t"; technology, team, time. We have the *technology,* he said. Nuclear is needed and CANDU is the only alternative to LWRs. The *team* is being challenged since the "program review" is, he said, just a polite way of saying "slash and burn". Our success to date has been built on partnerships and they are needed even more now. The *timing* is propitious, with a good chance of selling nine CANDUs over the coming decade, if financing can be arranged.

Eric Siegal, senior vice-president of the Export Development Corporation, picked up the theme of financing, which he described as a "major challenge". Nuclear presents special financing challenges, he said, involving large sums, political sensitivity, long terms, and technology transfers. He noted, however, that some countries can do their own financing, such as Korea for Wolsong 2, 3, 4. The size of financing needed means that many funding partners are required, including from other countries, especially when there is off-shore procurement.

Jean McCloskey, deputy-minister of Natural Resources Canada, addresses the CNA/CNS Nuclear Winter Seminar in Ottawa, February 1996.

Gail Tyerman of the nuclear bureau of Foreign Affairs continued on with an overview of the many agreements and memoranda of understanding required to facilitate nuclear trade. Their office had been very involved with the nuclear discussions at the G-7 meeting last year. An achievement this year in which Canada took a leading part was a memorandum of understanding with Ukraine to close down the two operating units at Chernobyl by the year 2000. Canada has committed $24 million to assist with the planning. A number of additional bilateral agreements had been concluded but, she warned, there was little likelihood of agreements with India or Pakistan. To a question on Canada's position on the use of military plutonium she replied, "it is under ministerial review".

Mike Lascelles, of the Canadian Environmental Assessment Agency, standing in for Bob Connelly, outlined the features of the new Environmental Assessment Act which was proclaimed just over a year previously in January 1995. The objectives of the legislation are to: integrate environmental considerations; promote public participation; achieve sustainable development; promote efficiency in the

review process. He noted that it deals only with projects, not with policies or programs. (AECL's deep geologic disposal concept would not be included.) Four sets of regulations have been issued: inclusion list, law list; exclusion list; comprehensive study list. Only a very few per cent of projects will require comprehensive study, he noted.

John McManus of the Atomic Energy Control Board spoke of the many initiatives under way at the AECB in this its 50th year. (His paper is reprinted in this issue of the *CNS Bulletin*.)

Probably the most positive message was presented by **Bernard Michel**, president of Cameco, in his *"Update on Uranium Mining"*.

He noted that current western world production was much less than consumption and that very soon the inventories that had been built up will be depleted which bodes well for the future. Canada (Saskatchewan) has the richest deposits of uranium, he observed, with concentrations as high as 22 per cent uranium. New mining techniques are being developed to extract these rich ores.

Peter Brown, of Natural Resources Canada, looked at the other end of the fuel cycle, waste management. Work is continuing on a policy framework for radioactive waste, he noted. The intent is to have a comprehensive and integrated policy which covers the interests of the federal government, provinces, and producers. He mentioned that an agreement had been reached just the previous month between the federal government and Ontario on the long term management of uranium mine waste.

Colin Allan, of AECL, provided an update on the deep geological disposal concept, from the 1981 federal/Ontario commitment to their submission of an Environmental Impact Statement in 1994. (See *CNS Bulletin*, Vol. 14, No. 1) Public hearings on the EIS will begin in March 1996 and, hopefully, the Panel reviewing the concept will render a decision in 1997. His closing comment was that this concept had had "the most rigorous review of any project in Canada".

The next three speakers dealt with low-level waste. **Dennis Wood**, chairman of the low Level Siting Task Force outlined some of the problems they had faced in trying to find a receptive site for the low level waste at Port Hope. **John Murphy**, mayor of Deep River, the only community that finally offered to accept the waste, commented that despite his residents' knowledge of radioactivity they still wanted a definite benefit it they were to accept the waste. The Deep River proposal and the Siting Task Force recommendation are still awaiting a decision by the federal government. **Grant Unsworth**, of Canatom, told the story of their trials in obtaining approval for a low-level radioactive waste transfer facility in Oakville which had elicited considerable public opposition. "It could happen to you", he warned.

To wrap up the day two speakers outlined the roles of their groups in winning public and political support for nuclear activities. **Emélie Lamothe**, of AECL-CRL, outlined the organization *Women in Nuclear* and its attempts to convince women that nuclear energy is safe and acceptable. (See her remarks elsewhere in this issue of the *CNS Bulletin*.) **David Shier**, spoke of the activities of the *Canadian Nuclear Workers' Council,* a volunteer group of union members, but not a union, which promotes nuclear energy within the union movement.

Jack Richman, president of the Canadian Nuclear Association closed the day with thanks to sponsors, staff, volunteers and those attending.

New WEB Address

The CNS homepage of the World wide Web, which is developed and operatd by Simon Day of the Golden Horseshoe Branch has a new address:

http://www.science.mcmaster.ca/cns/www/cns/cns.html

Call For Papers

2nd International Topical Meeting on Advanced Reactor Safety (ARS'97)

June 1-4, 1997
Marriott Orlando World Center
Orlando, Florida, USA.

ARS'97 will be embedded with the 1997 annual ANS conference. ARS'97 provides a forum to discuss: safety technology development of reactors for power generation, and for research, test, production and space reactors.

Papers are solicited on topics such as: passive system and fuel cycle improvement concepts; technological advances in I&C, severe accident issue resolution, PSAs, seismic response, containment performance; accident management; licensing and certification; economic viability of advanced designs; and, special topics such as plutonium disposition, tritium production and accelerator concepts.

Deadline for 600 word abstracts: May 1, 1996.

Author notification: July 15, 1996.

Full paper deadline: October 15, 1996.

Final paper submission: February 15, 1997.

Submit abstracts to:

Dr. Russi Taleyarkhan,
Technical Program Chair, ORNL,
P.O. Box 2009,
Bldg 9204-1,
Oak Ridge, TN
37831-8045, USA
Tel.: 423-576-4735
Fax: 423-574-0740
e mail: zrt@cosmail1.ornl.gov.

New Initiatives at the AECB

J.G.McManus

Ed. Note: *John McManus is Secretary General of the Atomic Energy Control Board and Secretary to the five member Board. He gave this overview of current activities at the AECB to the CNA/CNS Nuclear Winter Seminar held in Ottawa, February 6, 1996*

Introduction

This year marks the 50th anniversary of the establishment of the Atomic Energy Control Board, the oldest independent nuclear regulatory body in the world. As we head into the next fifty years, and a new century, there are a number of challenges that the AECB is addressing.

This paper outlines: our expectations with respect to new legislation and regulations; developments in attaining consistency in compliance activities; steps toward the application of cost-benefit considerations in regulatory decision-making; upcoming changes in the recovery of the Board's costs; and, finally, the progress of a major project designed to facilitate the AECB's transformation into a more fully effective, smoothly operating agency for the long term.

Legislation and Regulations

The *Atomic Energy Control Act* has served Canadians well since it was proclaimed in 1946, but the 50-year old statute needs replacement.

The current Act has only been amended once since 1946, when security was the focus. In 1954, the separation of regulation from promotion and development was enshrined in the Act following the formation of AECL.

In 1978, Bill C-14, the proposed Nuclear Control and Administration Act, which would have replaced certain sections of the AEC Act, died on the House of Commons Order Paper.

In 1996, the AECB's focus is on ensuring that nuclear energy is used in a manner that does not pose undue risk to health, safety and the environment.

Deficiencies in the Atomic Energy Control Act have been noted by the courts, the media, special interest groups, parliamentary committees and the Auditor General. In his report of November 1994, the Auditor General reported that the AECB has provided Canadians with assurance that the nuclear industry is operating in a safe manner, but he added that increased vigilance is required in these changing and difficult times. The AECB's President, Dr. Agnes Bishop, welcomed the Auditor General's observations and stated that new legislation would provide the platform from which to launch the regulatory initiatives necessary to meet the challenges of today. From discussions held with industry and other stakeholders, the AECB believes that there is widespread support for new legislation.

Some of the deficiencies we see in the current legislation include: the lack of formal powers for AECB inspectors; the low ceiling of $10,000 on fines; the lack of formal provision for public hearings; the lack of specific appeal provisions; and the inability of the AECB to hold polluters financially accountable for their actions or for the AECB to initiate remedial action and recover the cost.

The AECB would also like to see a change in the name of our regulatory agency. For years we have been receiving AECL's mail and they've been receiving ours. There's more to it than that, of course, and we need a name which is more reflective of our activities and which sets us apart from AECL.

Let me now turn to the area of regulations. Before dealing specifically with what the AECB is doing in this area it is appropriate to note recent developments at the federal level.

Last November, the federal government approved a new Regulatory Policy. The objective of this policy is,

> *"To ensure that use of the government's regulatory powers result in the greatest net benefit to Canadian society."*

The government, and that includes the AECB, is committed to working in partnership with industry, labour, interest groups, professional organizations, other governments and interested individuals to ensure that the regulations of the federal government are the best they can be.

The federal regulatory policy sets out criteria that require a clear demonstration of a problem, need or justification for federal intervention, and the assurance that regulation is the best alternative. The policy states that benefits must outweigh costs, and there must be a minimization of regulatory burden on everyone, including industry.

There is clearly an increased sensitivity within government to the concerns of business and industry. The AECB, while ensuring the safe use of nuclear technology and products, will do everything it can to live up to spirit of the new policy.

Regarding the AECB's regulations, the Auditor General commented on them and our framework, as well as the Act, in his 1994 report. He also noted that we frequently regulate through the use of licence conditions. We acknowledge this shortcoming which

arose from weaknesses of the present Act, and are planning to convert generic licence conditions to regulations.

The AECB has a great deal more control over its regulations than it does over the Act which governs us. Areas where improvements can be made in our regulations have been identified and work on improving our regulations has been underway for the past year.

As the basis for our work we have used the General Amendments. The General Amendments were intended to replace the existing Atomic Energy Control Regulations and, after years of work, appeared in Part I of the Canada Gazette in 1991.

After a great deal of deliberation, the AECB decided to break up the General Amendments into manageable parts to simplify the language, and, in some respects, to start over. We consulted widely on the General Amendments, so we kept and used that input in developing drafts of new regulations under the new Act. Our goal is to continue working on the regulations, consult informally, and distribute draft regulations soon after the Act is approved by Parliament. An exception is the Radiation Protection Regulations which were circulated for comment in 1991. We will have these published in the Canada Gazette soon for further comment in the formal part of the federal regulations-making process.

We look forward to receiving the industry's and public cooperation and assistance in the development of the new regulations. We are sure that these cooperative efforts help us regulate better, provide better service to Canadians and ensure that industry is not overburdened by regulation.

Consistency in Compliance Activities

Flowing from the requirements imposed by regulations is the important area of compliance. The need for the AECB to have a clear, consistent and defensible compliance policy has been reinforced as a result of recent court decisions that identified regulatory liability, as well as from comments from licensees and the Auditor General's recent report. With over 3600 licensees that vary from reactor operators to users of radioactive static eliminators, some variations in inspection and enforcement are necessary, but licensees should be aware of the AECB's policy on compliance so the Board's reaction to items of non-compliance will not be unexpected. To achieve this end, AECB staff is working on a policy to be applied to all licensees that would consist of the following five parts:

1] compliance promotion through prior consultation about requirements, promotion of internal monitoring and reporting, and the publication of documents to clarify requirements;
2] compliance assessment through staff reviews of reports and submissions from licensees;
3] compliance verification by mandatory reporting of information by licensees and by independently obtaining information by AECB staff engaged in inspecting activities licensed by the Board;
4] compliance investigation to obtain additional information so subsequent enforcement actions are soundly based;
5] compliance enforcement through directions from AECB staff, Board orders and/or court action. A policy of escalation will normally be followed to obtain the desired compliance. For instance, warnings will usually be given before more stringent action is taken.

Little of this is new but its organization and documentation in a consistent policy is.

The policy would also apply to non-licensees who are subject to the regulations. An example would be carriers and certain receivers of radioactive materials who must meet the Transport Packaging of Radioactive Materials Regulations.

The policy will require the development of divisional procedures to implement it, training of AECB staff in their application, and the development of criteria which staff can use to determine the extent of assessment and inspection required for different types of licensed activities.

Applying Cost-Benefit Considerations in Regulatory Decision-Making Process

The application of cost-benefit considerations to the AECB's regulation of the industry has been the subject of considerable work, and we are not alone in exploring this area. Recently, the trend in federal regulation is for the impact of regulations to be treated in a more quantitative manner. In 1992, the report of the House of Commons Standing Committee on Finance contained a recommendation that all costs and benefits should be estimated for major proposed regulations.

The cost-benefit issue also arose during the 1993 review of the AECB's regulations and regulatory process by the Advisory Panel on Regulatory Review set up by the then Energy Minister. A number of major licensees made representations to this panel on a variety of regulatory irritants. One of the recommendations of the panel subsequently submitted to the Minister was:

> *"that mechanisms be developed to examine cost-benefit issues and work towards some consensus of opinion among stakeholders: a task force on the subject could be an appropriate starting point."*

Quantifying costs is not easy for a regulatory agency like the AECB. It is not clear that we can simply accept at face value cost estimates supplied by a licensee. If the costs are high because of the inefficiency of a licensee, this should not be rewarded with a relaxation in requirements. On the other hand we do not want the AECB to have to employ a large number of planners and economists.

Much of the AECB's more difficult decision making is related to accidents which are assumed to occur

with a low frequency. Estimating the benefits, therefore, involves prediction of the frequency and consequence of such events with some confidence. Our experience to date is that our precision in predicting is not always very good, even using probabilistic safety assessment.

There is considerable uncertainty associated with the results of cost-benefit assessments, and it is not yet clear exactly what role cost-benefit will play in the decision-making process. Nuclear regulatory agencies in some other countries require that cost-benefit analysis be done, but the extent to which the results influence decisions is generally unclear, and certainly no nuclear regulatory agency puts constraints on its authority to make decisions solely or mainly on the basis of the results of cost-benefit analysis.

However, the AECB has been vigourously investigating the feasibility of developing methods for factoring cost-benefit considerations into its regulatory decision-making process for some time now. This work was initiated in response to requests by some licensees to introduce cost-benefit explicitly to the AECB decision-making process, and in answer to the federal policy requiring cost-benefit considerations to be taken into account in the regulatory process. Following some preliminary work by a consultant, an exploratory meeting was held with representatives of major licensees and other interested parties in March 1994. It was evident from the meeting that cost-benefit was a major preoccupation in some sectors of the industry. One conclusion was that the AECB should ascertain the experience with the use of cost-benefit analysis in other regulatory agencies.

Since all parties maintained a strong interest in the subject, further work was initiated under the AECB Regulatory Research and Support Program. The purpose was to investigate further the feasibility of including cost-benefit considerations in decision-making, and in particular to obtain information on the use of such considerations by other regulatory agencies, in Canada and elsewhere. This project was completed in June 1995, and the results were published in the AECB report INFO-0566.

(AECB publication INFO 0566, *The Asessment of the Costs and Benefits of Regulatory Decision Making,* a report by Price Waterhouse for AECB, June 1995.)

Following informal discussions with industry representatives, it was decided to form a working group to prepare a draft regulatory policy statement on the application of cost-benefit in regulatory decision-making. A number of experts were identified and invited to participate. The first meeting of the working group took place in Ottawa in November last year. A second meeting was recently held in Toronto. The group is chaired by a representative of the Atomic Energy Control Board.

The objective of the working group is to produce documented proposals for factoring cost-benefit considerations into regulatory decision-making, including:

- identification of types of decisions for which cost-benefit will be a consideration, and types for which it will not;
- a process by which the cost to a licensee of implementing a regulatory requirement can be reliably estimated, including both monetary costs and costs to the safety and health of workers and the public, and implications for the environment;
- a process by which the benefits of implementing a regulatory decision can be reliably estimated, including benefits to the safety and health of workers and the public, and implications for the environment; and
- a process by which the costs and benefits of a regulatory decision can be meaningfully compared.

The working group will be inviting non-members to make presentations at its meetings to obtain a sufficiently wide range of views on the subject. The final product of the group is expected to be a report containing a proposal for consideration by the AECB. If this initiative is successful, a consultative document will be produced and circulated to all stakeholders, including licensees, labour representatives, and public and special interest groups, to ensure that the views of interested parties are considered. Following the consultative process, it is intended that a regulatory policy statement on the use of cost-benefit considerations in the regulatory decision-making process be prepared and submitted to the Board for approval.

Cost Recovery

The AECB does many things that attract attention from its licensees, and one of these is charging fees. However, in this area it has no choice.

To comply with policy of the Federal Government, the Atomic Energy Control Board began collecting fees in 1990 to recover its costs for regulatory activities. Since then, the AECB has implemented two fee increases, the latest in 1994. The consultation process for our third fee amendment, which we anticipate implementing by this summer, is underway.

In accordance with the government's policy, the AECB is committed to full recovery of its regulatory costs for those licensees who are subject to AECB licence fees. Regulatory costs in this area make up approximately 85% of the total AECB cost. The remaining 15% is comprised of costs for non-regulatory activities and costs for regulating licensees such as hospitals that are exempt from the fees regulations. Our current estimates indicate that by 1997/98 our total annual operating costs will level out at approximately $45 million. This means that we must aim our annual revenue target at approximately $38 million to attain full cost recovery.

It is estimated that annual revenues from the current 1994 fees regulations will be approximately $30 million, or 80% of the cost recovery target.

The proposed 1996 fees regulations will generate annual revenues of approximately $34 million, or 90% of our target.

To date we have not achieved our full cost recovery target and are still catching up. The reasons for not attaining full cost recovery are:

a) in 1990 we did not start out at 100% cost recovery;
b) a two-year lag - fee increases have always been based on expenditures of two years before;
c) only partial fee increases have been implemented, resulting in a gradual move towards attainment of full cost recovery. This gradual move to full cost recovery eases the burden on our licensees.

Fees collected accrue to the government of Canada and are NOT at the disposal of the AECB.

Project 96

Those having regular dealings with AECB staff, since last fall may have noticed somewhat of a preoccupation with a special undertaking called Project 96 and Beyond. This large project, which involves a significant number of staff at all levels, was initiated by the President as a follow-up to three stimuli: her extensive interviews with personnel in the first months of her appointment; a consequent exercise wherein the strengths and weaknesses of the AECB were compiled from staff and management input; and the Auditor General's report in 1994.

Purpose of the project is to provide detailed recommendations for improvements in specific regulatory, management and related practices at the AECB, thereby helping facilitate its transformation into a more fully effective, smoothly operating agency for the long term. One important goal is to begin seeding a new management culture within the institution that will help it become a single, unified team operating in an integrated, up-to-date, businesslike manner.

The project began in mid-August last year, and is to be completed, with all recommendations provided to the President, by June 30 this year.

No project with the Presidential support, purpose, scope, scale, management and other features of Project 96 and Beyond has ever been undertaken at the AECB.

Managed by a Project Manager who reports to the President, Project 96 comprises 22 individual tasks grouped into three categories: regulatory; management; and general. Some task examples are:

- Determination of Regulatory Effort;
- Interaction with External Organizations and the Public;
- Authority, Responsibility and Accountability;
- Service Standards;
- Documentation.

Each task is in the charge of a "Task Leader" who heads a small "Task Group" of up to four individuals.

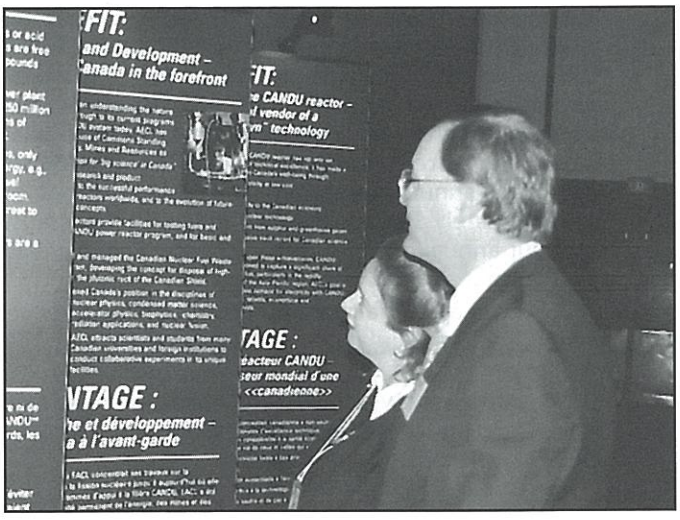
Through a process of constituency representation, the entire staff of the institution is consulted formally by each Task Leader twice during the project in accordance with a documented procedure. In addition, Task Leaders are also required to conduct formal consultations with certain management and staff groups, and to inform the Executive Committee of the preliminary results of their efforts. The purpose of this demanding process of consultation is to ensure that the project benefits as much as possible from the views of the staff, and at the same time that the recommendations which result are widely supported.

The impact of the Project 96 recommendations on the way the AECB operates is expected to be quite remarkable.

Conclusion

In conclusion, it is fair to say that the AECB will not lack for challenges over the next few years, and we can anticipate significant changes. As our President said to the Ottawa Branch of the CNS last spring,

"...we must be prepared to take what change brings, and change what it takes to do the job that society and the nuclear industry expect of us."



AECL's Jean Cooper and M.P. Ian Murray puruse the AECL display at the CNA/CNS Nuclear Winter Seminar in Ottawa, February 1995.

Women in Nuclear

Emélie Lamothe

Ed. Note: *Emélie Lamothe, a health physicist at AECL's Chalk River Laboratories, is the current chairperson of the Women in Nuclear organization in Canada. WIN is allied with and supported by the Canadian Nuclear Society and Emélie is a member of the CNS Council. The following article is a slightly edited version of her notes for a presentation to the CNA/CNS Nuclear Winter Seminar held in Ottawa, February 6, 1996.*

The international organization *Women in Nuclear* was founded in Helsinki in May 1992. WIN is a group of women working within the nuclear industry, whether in the technical areas or in communications, who give their time to communicate with the general public, especially with female audiences, on the nuclear debate. WIN is currently establishing local chapters throughout Canada.

The key concept of WIN is to appeal to women as well as men in the discussion about nuclear energy, using reason and emotion, not just facts,

WIN aims to:

- communicate risk and benefits of nuclear energy and radiation that includes the lay man's perception of risk; and
- to communicate the nuclear industry's uniquely rigorous approach to safety.

Contrary to the belief in some quarters, WIN is NOT about employment equity. It is not about knitting needles and home fashions. So then, what precisely is WIN?

WIN is, as noted above: professional women working within the nuclear industry, medicine, academia and communications who give their time to communicate with female audiences on the nuclear debate.

Surveys in most countries show, that the attitudes of women towards nuclear energy differ considerably from that of men. Women tend to be more opposed to the use of nuclear power. Women are more likely to mention the problems associated with nuclear power than the benefits. Since in most democratic systems, 52% of the people who cast their vote are now women, they are of major importance when deciding on energy options, especially nuclear power.

Our industry, as in other technical and scientific areas, has largely been dominated by men, the use of jargon, the use of facts and an emphasis on economics. Within this context, women view the nuclear industry as part of the world of technology responsible for weakening human relationships and ignoring the human dimension of life, not to be trusted and a potential threat to the safety of future generations. Women believe that their priorities of environmental preservation, quality of life and social welfare are reason enough to oppose nuclear energy. It is ironic that our industry has a solution to many of these concerns.

In the WIN communication program, there are three key messages. These concern: radiation, safety, and protecting the environment.

On radiation:

Radiation is part of everyday life, and used in the right way, can be beneficial.

Radiation is unquestionably a technical issue and a marketing issue but as a colleague of mine once said, *"... from the perspective of a communicator, radiation transcends these dimensions. It's a social issue."* Radiation is central to all nuclear issues. The concerns about safety and wastes are concerns about radiation. The costs of nuclear are high because of the special radiation protection that must be engineered into the facilities. Because the terminology surrounding it is complex and forbidding to the public (which includes lawyers, MD, engineers, scientists, teachers, farmers, miners, ordinary men and women), radiation almost defies explanation. People are afraid. No matter what you think, for these people, these fears and concerns are real. To be honest, how many of us would willingly expose ourselves to a few extra mSv or drink water with a "higher than allowable level of tritium"?

On safety:

Nuclear safety needs to be put in perspective. Safety is not just a technical issue; it is also an emotional feeling. Nuclear safety needs to be seen in an overall context and put in perspective by comparison with safety in other industries.

It is one thing for my husband to say, "I think that this is safe". It is quite another when I say, "You know, I spent a good part of my pregnancy on top of a research reactor. Yes, I was concerned. But after looking at exposure data, and shielding and safety in-depth concepts, I felt that it was safe enough for me and my baby to continue my work. And except for being perfect, my children are fine." My words usually have a bigger positive impact.

On protecting the environment:

Women want their children to have a sustainable world. Nuclear energy can make an important contribution to providing a sustainable energy supply.

Many of us have long held (and to a certain extent

still do) the belief that if we gave all the facts, we would solve the communication problem and win (no pun intended) the public over. Unfortunately, this is not the case.

In 1990 October, the Ontario Advisory Council on Women's Issues produced and widely distributed a book entitled "Women and the Environment". Needless to say that the section dealing with radiation was mostly wrong. The concluding sentence of that section is, "This is a sober reminder that it is no longer enough for women to protect their own bodies to ensure that they bear healthy children." As an aside, the Chalk River Career-Women's Association did prepare and send a rebuttal to the Advisory Council.

The message that things are OK, or under control has to come from members of that specific community. Consequently, WIN is encouraging its members to become spokesperson in their own communities.

WIN's communication strategy is based on integrating emotion and reason to achieve communication on three different levels: the technical/scientific level; the economic level; and the level of ethical values/emotions. The key concept is that communication should always concentrate on the human aspect. Because of the nature of our target audience, WIN very much uses a grassroots approach.

WIN is currently establishing local chapters throughout Canada. The Canadian group supports the objectives of WIN international and will align ourselves with their communication program. We do this because we believe in this technology.

We realize that our numbers are small, that we can't do everything. Because corporate support has not been seen yet we are affiliating with other professional groups, such as: Women in Mining; Women in Science and Engineering; Women in Nuclear Medicine; and the Canadian Federation of Business Women and we are working with the Girl Guides of Canada. WIN is creating a "homepage" on the Internet.

We acknowledge that there is tough competition with other nuclear organizations for both members and funds. On the other hand, we are a new pro-nuclear group that is targeting women. Certainly, as the public hearing process becomes a fundamental part of the nuclear industry, it will be of enormous benefit to the industry to support this network of women who endorse the WIN philosophy.

Perceptions of Risk

Ed. Note: *In her talk on* Women in Nuclear *Emélie Lamothe noted that men and women judge risks differently. That prompted the following extract from one of the few studies conducted in Canada on the perception of risk.*

In 1993 the then Department of National Health and Welfare (now Health Canada) sponsored a study on the perception of health risks in Canada*. One of the findings dealt with the differing views of men and women.

The report states:

> The differences [in concern about risks from nuclear power and chemicals] between men an women in the present study appear to be larger than those observed previously. Gender differences exist even for perceptions of non-chemical and non-nuclear hazards. These results also demonstrate that the magnitude of gender differences in risk perception varies considerably across hazards.

The report also notes some regional differences, e.g., residents of Quebec perceive much more risk from nuclear power and nuclear waste than do residents of Ontario.

The key findings of the study were:

1. The Canadian public reported a high degree of perceived risk for many hazards. People are quite aware of individually chosen lifestyle risks that are judged serious by health and risk professionals. However, there was a tendency to see AIDS, drugs, and alcohol as posing much higher risk to society in general than to oneself. There was also a great deal of concern expressed regarding health risks associated with industrial pollution and risks from certain medical devices. Perception of risk from nuclear power and nuclear waste were particularly high.
2. Perceptions of risk between pairs of hazards tended to be positively correlated. That is, persons concerned about one hazard were more likely to be concerned about other hazards as well.
3. There was a high degree of concern about chemical products and chemical pollution. There was almost complete agreement (93.4%) that land, air, and water are more contaminated now than ever before. Fewer than half (43%) of respondents agree that use of chemicals has improved health more than it has harmed health. About 75% said that they try hard to avoid contact with chemicals and chemical products. This response was linked to a widespread belief that even small exposures to chemicals could be harmful.
4. There was a widespread belief that a risk-free environment is achievable in Canada and an unwillingness to accept some risks to one's health in order to aid the economy. A majority would, however, accept some risk in order to achieve the potential health benefits of medicines or medical devices.
5. There were sizable effects of gender, age, education and region of residence that need to be better understood. Women generally rated health risks higher than men and less educated persons generally had higher perceptions of risks than did people with more education. Residents of Quebec stood out from other respondents in their attitudes and perceptions.

* Report 93-EHD-170, Health-risk Perception in Canada, A research report to the Department of National Health and Welfare.

GENERAL news

Pioneer regulator dies

A pioneer of Canadian nuclear regulation, **Dr. Donald Dewar,** died suddenly in London, Ontario on December 8, 1995.

Although very influential in the development of regulations and the policies of the Atomic Energy Control Board, his modest approach made him little known outside of those with whom he direct contact.

Don Dewar joined the AECB in 1946, just weeks after it was established with the passing of the Atomic Energy Control Act, after serving as a chemical warfare expert during World War II. For the next almost three decades, until his retirement in 1974, he served first as Scientific Adviser then as Senior Scientific Adviser to the AECB. Until 1958 he was the AECB's only scientific staff. He oversaw the early growth of the staff and was essentially in charge of all of the scientific staff until his retirement.

His position required him to deal with senior officials in all of the departments and agencies involved in nuclear affairs and, after the commercialization of nuclear activities, with senior officers of companies and utilities, a function which he carried out with great tact and true understanding.

Dr. Dewar set the early tone of operation at the AECB, emphasizing the importance of achieving results (always in the country's interest) rather than seeking credit. As a consequence he initiated the practice (almost heretical in government circles at that time) of working cooperatively with other departments and agencies, both federal and provincial, a policy which is still largely followed by the AECB. His legacy will live on.

AECB Turns 50

This year the Atomic Energy Control Board celebrates its 50th anniversary. It is the oldest independent nuclear regulatory agency in the world.

The Atomic Energy Control Act was introduced into the House of Commons in May 1946 and proclaimed in October the same year. The main thrust of the Act was to create the AECB. As stated by C. D. Howe, the minister responsible, the purpose of the Act was to *encourage research ... while taking adequate security measures against the use of the material from which atomic energy is derived as a weapon of war.*

Initially the Board was responsible for research, then being carried out by the National Research Council at its Chalk River Project, as well as control. This changed with the only significant amendment to the AEC Act in 1954. With that amendment, Atomic Energy of Canada Limited, which had been created in 1952, reported to a Minister and not the AECB. From then on the AECB's role was strictly regulation.

In the early years the AECB's primary focus was on security. Regulations dealing with health and safety were not issued until 1960. The staff was very small in number, there being less than a dozen in 1960. Now the AECB staff numbers about 400.

As noted in the article on the Winter Seminar the government expects to table (and pass) a new Act this year which will result in a new name for the AECB.

CEA Conference

The Canadian Electrical Association, the organization which represents all the electrical utilities, is holding, "Electricity '96, a technology conference and exposition for the electrical power industry", in Montreal, April 27 to May 3, 1996.

A special session will be held on nuclear power on Wednesday, May 1, featuring four invited papers:

- Hydro Quebec Perspective on Operating a single Unit Nuclear Power Plant, by Paul Lefreniere.
- The CANDU Reactor's Fuel Cycle Flexibility, by Dan Meneley
- Bruce "A" NGS; Business management, Economics, Recent Performance and Prospects, by Ken Talbot
- Developments of CANDU Nuclear Power Plant Design, by Joe Hopwood.

For information regarding the special session contact, Neil Craik at Maritime Nuclear in Fredericton; tel. 50-6485-4490, Fax 506-458-3167.

A 25th Birthday for Pickering

If the age of a nuclear power plant is dated from the start-up of its reactor then Pickering unit 1 turns 25 in February 1996.

It was on February 21, 1971 that the reactor of Pickering unit 1 went critical. Commercial service began later that same year.

Elgin Horton was the station manager at the time and Gary Turcotte the commissioning engineer in charge of start-up. They are now both retired. Zig Domaratzki, now Director General at the Atomic Energy Control Board, was the AECB's project officer overseeing the operation. Zig recalls that, unlike earlier reactors such as NRU, NPD, and Douglas Point that all started up in the small hours of the night, Pickering unit 1 started up about noon. The procedure of raising the moderator began at about 8 a.m. and was aborted once by dumping the moderator because of an anomalous drop in the neutron countrate. Otherwise the start-up reportedly went smoothly.

The Pickering story began in the early 1960s, after the start-up of NPD in 1962 but before the completion of Douglas Point in 1967. In those days of growth Ontario Hydro needed more generation and became convinced that nuclear was the way to go. However, financing was then (as now) a stumbling block. After considerable negotiations a deal was worked out in 1964 for the first two units whereby Ontario Hydro would invest the equivalent price of a conventional thermal plant (then $100 a kilowatt) and the Province of Ontario and the federal government, through AECL, would loan the difference. Ontario Hydro subsequently decided to build units 3 and 4 on their own. The operation of the plant)Pickering "A" was so successful that AECL received a significant revenue from it for many years.

Technically Pickering was a significant expansion. The operating NPD plant was only 20 megawatts and the still unfinished Douglas Point just 200 megawatts. Among the many basic changes in design was the size of the pressure tube which, after considerable argument, was set at 4 inches diameter rather than the 3 1/2 inches used in the first two CANDU reactors.

Also, to meet concerns of the Reactor Safety Advisory Committee of the Atomic Energy Control Board, a special containment design was conceived - the "vacuum" system - which subsequently was used on all Ontario Hydro's multi-unit nuclear stations.

Along, we are sure, with all other members of the Canadian nuclear community, we congratulate all involved with Pickering now and in the past on reaching the "quarter-century" mark and look forward to the plant still running well in another 25 years.

A century of radioactivity

It was a hundred years ago this spring, in 1896, that radioactivity was first observed. As with some other great discoveries this was serendipitous.

Just the fall before, in 1895, Wilhelm Roentgen had discovered X-rays by chance while conducting experiments with a Crooke's vacuum tube. He observed that some invisible rays from the tube made fluorescent material glow.

In the spring of 1896 the French scientist Henri Becquerel placed some uranium near some wrapped and sealed photographic plates and found they had been exposed as if by visible light. For that discovery and the explanation of the source of the rays Becquerel and his co-workers Pierre and Marie Curie won a Nobel prize.

After many painstaking and laborious experiments the Curies went on to extract from the uranium the elements radium and polonium which were much more radioactive than the uranium. For that work Marie Curie won a second Nobel prize, the only person to have done so.

The work spawned a flurry of physics work in Europe and America. One of the leaders was Ernest Rutherford who discovered the nucleus in 1911 and developed a concept for the structure of the atom. Rutherford spent a number of years at McGill University in the first decade of this century.

AECL Moves to ISO 9000

Atomic Energy of Canada Limited is moving towards registration under the ISO 9000 system. Workshops were held in Chalk River and Sheridan Park the end of January and early February to introduce managers and staff to the system.

ISO 9000 is a set of quality assurance standards issued by the International Standards Organization. It is a generic system wherein an organization creates and maintains a management system that will ensure that the quality of its goods or services are what they are stated to be. Registration as a ISO 9000 organization is rapidly becoming a prerequisite for doing business internationally, especially in Europe.

Hydro Quebec has already adopted ISO 9000 for some of its activities and expects to expand the scope this year. For instance all major suppliers, including engineering firms, will be required to be registered to one of the ISO 9000 levels.

ISO 9000 is the overall general guideline. ISO 9001, 9002, 9003 are the standards setting out requirements. ISO 9001 covers all aspects from design to testing, ISO 9002 excludes design, and ISO 9003 deals only with inspection and testing.

The workshops were organized by Shami Dua, Manager of Quality Assurance in AECL, and his staff. They will be overseeing the efforts needed for AECL to be registered. Registration is conducted by several companies under the aegis of the Standards Council of Canada.

DEADLINE

The deadline for the next issue, which will be published about the end of May, will be **Friday, May 3, 1996.**

CANADIAN NUCLEAR SOCIETY
bulletin
DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

New Report on Chernobyl Available

The Nuclear Energy Agency of the Organization for Economic Co-operation and Development, based in Paris, has just released its report, CHERNOBYL TEN YEARS ON: Radiological and Health Impact. Prepared by the OECD-NEA's Committee on Radiation Protection and Public Health the report provides:

- data on the dispersion and deposition of radionuclides from the Chernobylaccident of April 1986;
- estimates of the radiation doses received by clean-up crews, nearby populations evacuated and remaining, and populations outside the former USSR;
- evaluation of the health, agricultural and environmental impacts of the accident and potential risks for the future, and;
- discussion of the lessions learned by OED countries from the accident.

The report is available, free of charge, from: Publications Office, OECD Nuclear Energy Agency, Le Seine St. Germain, 12 boulevard des Iles, 92130 Issy-les Moulineaux, France.

Public Hearings Begin on Deep Geological Disposal Concept

The Environmental Assessment Panel for the Nuclear Fuel Waste Management and Disposal Concept has announced that public hearings will begin in March 1996.

The hearings will be in three phases. **Phase I** will deal with: criteria for safety and acceptability; burden on future generations; social, economic and environmental implications; and, site selection criteria.

Phase II will focus on scientific and technical issues. **Phase III** will cover essentially the same topics as Phase I and also seek recommendations to assist governments in reaching decisions.

The schedule for Phase I hearings is:

March 11 - 15	Toronto
March 25 - 26	Pickering
March 27 - 29	Toronto
April 29 - 30	Thunder Bay
May 1	Sudbury
May 2	Chalk River

For more information contact:

Guy Riverin
Canadian Environmental Assessment Agency
Hull, Quebec
K1A 0H3

Tel. 819-997-2244
FAX 819-994-1469

Policy on Presentations

At the meeting of the CNS Council on 19 January 1996 the policy on public presentations (in the name of the Society) was reaffirmed and clarified. This was prompted by a recent situation in which a member made a presentation which was not endorsed by Council and with which Council did not agree.

The Society encourages its members to communicate on nuclear issues and make presentations. However, when presenting subjective, personal views members should NOT do so in the name of the Society unless the statement or presentation has been endorsed by Council. This means that in such cases members should NOT use CNS letterhead or make specific reference to the Society or its branches or divisions.

If they have any doubt about the applicattion of this policy, any member intending to make a public presentation or statement should contact a member of the Executive of the Society (see box on inside back cover of this issue of the CNS Bulletin).

CALL FOR PAPERS

46th Canadian Chemical Engineering Conference Symposium on Chemical and Nuclear Engineering

Kingston, Ontario
September 29 to October 2, 1996

Papers are invited on work related to: Materials in Nuclear engineering; Radiation Processing of Materials; Chemistry under Radiation; Water Chemistry; Chemical Processes in Nuclear Fuel Cycles; Chemical Processes in Nuclear Power Plants.

Contact: Dr. C. C. Hsu or
E. W. Grandmaison
Department of Chemical Engineering
Queen's University
Kingston, Ontario K7L 3N6

CNS news

BRANCH NEWS

Bruce

A very full program has been organized.

On November 14 (1995) Dr. Ian Hastings of AECL - CRL spoke about the proposed Irradiation Research Facility. In addition to the regular attendees two young high-schoolers and their mother attended, attracted by the advertisement in the local newspaper.

On December 7, Dr. William Garland of McMaster University addressed the Branch on "The McMaster Research Reactor - The Accident, Lessons Learned, and the Future".

January 7 (1996) Dr. Ron Maruska of Ontario Hydro provided insights into the controversial topic of "Tritium in Drinking Water".

On February 8, Dr. Bob Stepaniak, also of Ontario Hydro, gave an overview of "CANDU Chemistry - the 1st 30 years".

Ted Dunstan, the AECB Senior Project Officer at Bruce, is scheduled to talk March 5 on "The Regulator's Viewpoint" and on April 11 Eric Jelinski, of the Darlington staff, will speak on his special interest, "Hydrogen as a fuel source".

The Branch is coordinating with the Darlington, Pickering and Sheridan Park branches to organize seminars by former nuclear submarine commander Philip Klintworth.

Darlington

On December 14, Dan Meraw gave a summary of his experiences as a member of an IAEA OSART team reviewing the Ignalina NGS in Lithuania.

A visit to the Ontario Hydro Grid control Centre in Clarkson is still being organized.

Golden Horseshoe

The Branch's homepage on the World Wide Web has a new address:

http://www.science.mcmaster.ca/cns/www/cns.html

In January, Dr. Dan Meneley, AECL Chief Engineer, presented an informative and detailed description of the various functions and responsibilities of the Chief Engineer's Office which ranged from quality assurance, to pioneering ideas and resolving issues in areas of fuel channels, systems engineering, reactor physics, fuel and thermalhydraulics, control and instrumentation, material engineering, safety and licensing, future plant concepts, and system chemistry. Dan also clarified the distinction between science and engineering and their role in AECL.

The Branch is planning another Career Night after the successful one last year. It will be held Thursday, March 21, at McMaster University. For information contact Robert Leger at 905-525-9140 ext. 22890.

Also, the Branch is producing postcards picturing the McMaster Nuclear Reactor as a fund-raising venture and is investigating the possibility of a video seminar with the Sheridan Park branch.

Manitoba

Morgan Brown has taken over as Branch chair from David Wren who has moved to Sheridan Park for a six-month assignment.

On November 14 (1995) Dr. Jovan Jovanovich of the Physics Department, University of Manitoba, gave a seminar on the risks of low-level radiation under the title "Value Judgements in Radiation Protection Philosophy - time for Changes ?" Morgan Brown, vice-chair of the Branch provided the following summary.

Dr. Jovanovich's abstract stated, *When this analysis of value judgements is combined with some new and old scientific information; information that is consistent with the existence of a threshold for radiation harm, or even hormesis, a conclusion is reached that the basic principles of the present radiation protection system, including the ALARA principle, should be changed from the ground up.*

He made some interesting comparisons, for example, that the present dose limits for the public are equivalent to the increase in cosmic ray irradiation received by moving from the 2nd to the 7th floor of an apartment building. We need to re-examine the low dose limits, he said. Money spent maintaining such ultra-conservative low limits would be better spent improving public infrastructure. Dr. Jovanovich argued that limits should be a function of age, with higher limits for older workers.

His talk elicited vigorous discussion.

Future talks are planned on the media and the nuclear industry, and CANDU international marketing

The Branch is organizing its second annual Manitoba schools contest in which the winning class gets a trip to the Whiteshell Laboratories and the Underground Research Laboratory.

Ottawa

On January 22, the Branch joined with the local branch of the Canadian Aeronautics and space Institute to host a talk by Dr. Tom Cousins, head of the Radiation Effects Group at the Defence Research Establishment Ottawa.

Dr. Cousins outlined the activities of his group and then spoke about three topics: the deleterious effect of space radiation on modern semiconductor electronics (which was a cause of the ANIK failure); radiation dosimetry; and a newly developed thermal neutron activation technique for detecting non-metallic land mines.

On January 30, the Branch held a reception for Peter Walker, Canada's ambassador to Austria and our Permanent Representative to the International Atomic Energy Agency. This unusual and unplanned event resulted from an invitation from the Department of Foreign Affairs. A number of senior officials from companies and departments associated with the nuclear field attended.

The Branch is very involved with the 21st CNA/CNS Student Conference which will be held in Ottawa, March 15, 16. Chairman Mohamed Lamari and vice-chairman Sadok Guellouz are co-chairing the student conference.

Pickering

On November 22, Pierre Charlebois, Director of the Pickering Nuclear Division, spoke on "PNGS - 95, a Year in Review and Directions for the Future". He discussed recent performance indicators, the appearance of some worrisome trends, and proposed ways of reversing those trends. These include the definition of new and significant performance targets and the strong encouragement of staff involvement in identifying ways of improving quality and efficiency.

Quebec

On January 18, Dr. Daniel Rozon, head of nuclear engineering at Ecole Polytechnique, made a presentation on the myths and realities of nuclear energy in Quebec.

He presented basically the same material he presented to the public hearings on energy which took place in Quebec last fall. He encourages the government to look at nuclear energy with renewed enlightenment. He encourages the government to seriously consider and evaluate the implementation of another NPP at the Gentilly site. Another plant on that site should be easy to build and would help maintain nuclear expertise in the province. It would help Hydro Quebec develop base load capabilities without affecting their hydraulic program considering the inevitable growth of electrical energy demand in the province.

Dr. Rozon also made a plea in favour of the IRF saying that research in fundamental science is suffering in Quebec and in Canada and that such a tool is essential to keep the country participating in the world race for technology and fundamental science.

Saskatchewan

Over the period October 26 to 30, the Branch organized several seminars by Beth MacGillivray, a registered Nuclear Medicine Technologist at the Ottawa General Hospital. Following is a report from Larry Christie, Branch Program Chairman, on Ms. MacGillivray's visit.

For many Canadians, the word "nuclear" drums up images of nuclear weapons, Chernobyl, and scientists in white coats with an intimate knowledge of white rats.

However, after they meet Beth MacGillivray, a Registered Nuclear Medicine Technologist from Ottawa General Hospital, all that changes.

Beth works in the nuclear medicine part of the Canadian nuclear industry and she brings to audiences a warm, compassionate presentation that dismantles stereotypes about the industry.

After hearing her presentations, high-school students are enthusiastic about careers in science and technology. This is especially true of girls who have up to now shied away from such career paths. As a student in high school Beth was "encouraged" to do an essay on the Atomic Bomb by a science teacher who observed her watching soap operas during study period. Preparation of the essay taught her, she observes tongue in cheek, "everything there was to know about radiation".

So when a small notice at the Guidance Counsellor's office about a career in nuclear medicine piqued her interest, she began a trail that led to using nuclear technology to save lives.

Beth's polished presentation achieves a wonderful purpose: when she speaks to people in the nuclear industry, it makes them proud! Nuclear workers at AECL and Cameco in Saskatchewan left her presentations with tons of information about nuclear medicine, diagnostics, treatments and techniques.

Saskatchewan audiences took a personal interest when she revealed that a new diagnostic technique using radionuclides as a follow-up to mammography might drastically cut biopsies in suspected breast cancer cases. This could reduce painful surgery in many patients.

"Her message gives people in the industry something to be proud of, something to talk about, and it's the kind of information more Canadians should have", states Walter Keyes, Chairman of the Saskatchewan Branch of the Canadian Nuclear Society, sponsoring agency for Ms. MacGillivray's visits.

The Saskatchewan Branch of the CNS actively promotes activities in support of the nuclear industry and in the past has hosted:

* Nobel recipient Dr. Rosalyn Yalow who addressed the subject of women in science,
* Dr. Margaret Maxie, Professor of Bioethics at the University of Houston, who debated the ethical aspects of nuclear technology with local anti-nuclear advocates,
* the late Dr. Dixie Lee Ray, former Governor of Washington and Chair of the US Nuclear Regulatory Commission, who shared a wealth of scientific, public policy and political insight,
* Mr Philip Bane, President of the Nuclear Energy Institute who outlined the role of nuclear power in the context of world electricity requirements,
* Dr. Karen Strauss of Johns Hopkins University, who spoke on the topic of Advocacy and Accountability, and
* Jane Ohara, James M. Minifie Scholar who talked about the role of media in reporting science and public information.
* Nobel Laureate Dr. Bertrand Brockhouse.

Sheridan Park

The Branch held two seminars in November.

On November 16, Dr. Paul Unrau, of AECL CRL, gave an interesting talk on "Genetics, Biology, and Risk Assessment". He contends that there may be a large genetic component to any particular individual's risk of harm from radiation. Quantitative information may start to be generated within a decade, he believes.

Less than a week later, on November 21, Dr. Dan Meneley, AECL Chief Engineer, spoke on "Why do We Need a Chief Engineer's Office ?". He spoke of the many and varied activities of his staff such as: design reviews, consultations, support for marketing, etc. Ultimately, he stated, the Chief Engineer is responsible for the CANDU product.

On January 23, Dr. Ken Dormuth, AECL WL, spoke on "The Status of the Review of AECL's Nuclear Fuel Waste Disposal Concept".

Rummery Retires

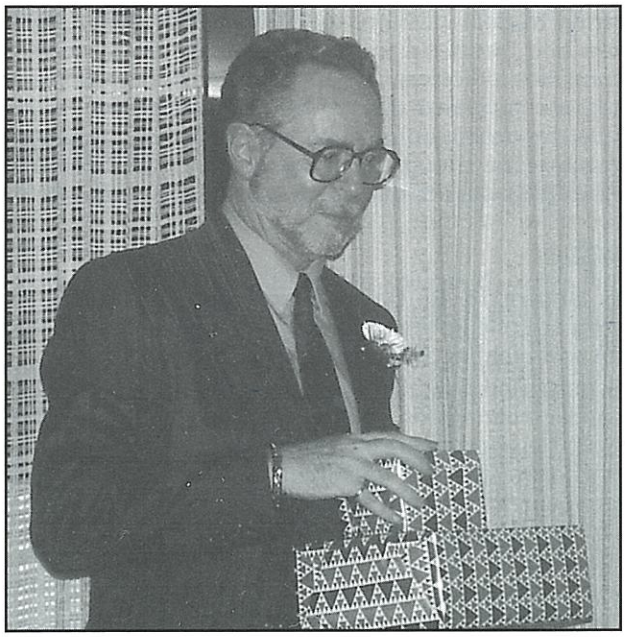
Dr. Terrance E. (Terry) Rummery, a Fellow of the *Canadian Nuclear Society* and former president of AECL Research retired from Atomic Energy of Canada Limited at the end of 1995.

Terry joined the Research Chemistry Branch at the Whiteshell Laboratories of AECL in 1971 and became head of the branch in 1976. In 1979 he was appointed as the first head of the program to develop the concept for nuclear fuel disposal. In 1985 he took a detour as head of marketing for Yugoslavia and the Netherlands at AECL CANDU at Sheridan Park.

He was named acting president of AECL Research in 1989 and confirmed in that position in 1990. While in that role he also served as acting president of AECL Corporate for two periods during 1993 and 1994. With the re-organization of AECL in 1995 Dr. Rummery spent a few months as Senior Scientific Adviser until his retirement.

He was named a Fellow of the Canadian Nuclear Society in 1993.

Terry continues to live in Manotik (near Ottawa) and is involved in teaching at Queen's University and other activities.



Terry Rummery holds some of the gifts he received at a retirement party held in Petawawa in December 1995

Short Course on the Role of Reactor Physics in CANDU Power Plant Engineering

A review by Pamela R. Gomes-Feder

This fall, for the first time ever, the Canadian Nuclear Society sponsored a course entitled, *"The Role of Reactor Physics in CANDU Power Plant Engineering"*. The course, held from November 6 to 8, 1995 at the Holiday Inn in Sheridan Park, Mississauga, attracted 44 participants from all across the Canadian nuclear industry. AECL was well represented, with attendees from Sheridan Park, Chalk River, Whiteshell and Saskatchewan. The remaining attendees were from Ontario Hydro, Hydro-Quebec, New Brunswick Power, GE Canada Inc., KEPCO, SAIC Canada, KAERI, McMaster University, University of Toronto, and Royal Military College. In his opening remarks, Dr. Dan Meneley, Chief Engineer of AECL, remarked that it was refreshing to see so many people interested in the field of CANDU reactor physics.

The course was designed for scientists and engineers with a variety of backgrounds in the Canadian nuclear industry. The specific objectives of the course were:

- to provide scientists and engineers, not involved on a daily basis with reactor physics, with an overview and an appreciation of the relevance of reactor physics to their work;
- to provide an introduction to CANDU reactor physics for scientists and engineers entering the field of reactor physics;
- to provide the basics of reactor physics to junior scientists and engineers involved with reactor physics.

The course was organized in six sessions and was presented by lecturers from AECL. Each session is summarized below.

The session on CANDU lattice physics and its influence on overall plant design was presented by Dr. M. Milgram of Chalk River Laboratories. Dr. Milgram covered the basics of reactor physics in a comprehensive but easy to understand manner. He explained the significant role played by reactor physics in the design of the CANDU reactor. For example, in order to have neutron economy when using natural uranium fuel, heavy water was chosen as the moderator, and the horizontal channel design was chosen for on-power fuelling.

Mr. D. Jenkins of Sheridan Park presented a session on reactor statics and fuel management. Mr. Jenkins reviewed the basic characteristics of the reactor physics design of the CANDU reactor, before discussing the methods of physics analysis, physics computer codes, and in-core fuel management.

Dr. A.L. Wight of AECL - Saskatchewan presented a session on reactor dynamics and control. A detailed discussion of neutron kinetics, including point kinetics equations and spatial kinetics equations, was presented. The control of reactivity in a CANDU reactor was also covered in depth through the discussion of reactivity control devices, power distributions and spatial power changes.

Mr. C.R. Boss presented a session on radiation shielding and dose management, noting the three methods of reducing radiation exposure - minimize exposure time, maximize distance from the source, and provide shielding. He identified the sources of doses in a CANDU 600 and described the shielding design. He also discussed the radiation levels in the different types of accessible areas. It was emphasized that the radiation levels are usually lower than the required levels since the station is designed for the weakest point of the shielding.

Mr. H.C. Chow presented a session on the role of physics analysis in reactor safety and licensing. Mr. Chow summarized the reactivity effects due to changes in core parameters. He discussed the physics analysis for a large LOCA, an in-core LOCA, and for the determination of the guaranteed shutdown state (GSS) poison requirement. He also discussed compliance with respect to channel and bundle limits.

Mr. P.S.W. Chan presented a session on advanced fuel cycles and future plant design requirements. Participants were told that the CANDU reactor dynamics is insensitive to the type of fuel. The natural uranium requirements and fuel disposal requirements were presented for eleven fuel cycle options, including slightly enriched uranium fuel cycle in CANDU, LWR plutonium and LWR uranium recycled in CANDU, and the mixed oxide (MOX) fuel cycle in CANDU. The advantages of flexibility in fuel design and in fuel management were discussed. Advanced topics such as thorium fuel cycle and actinide burning were also discussed.

In summary, given the high quality of the presentations and course notes, the willingness of intructors to interact with the participants, and the low cost of the course ($440 for CNS members), I would definitely recommend this course to others.

Pamela R. Gomes-Feder is a Nuclear Design Engineer in Ontario Hydro Nuclear's Reactor Safety and Operational Analysis Department. She has extensive experience in reactor containment, public affairs and nuclear emergency planning.

First Anniversary Cross Section: No. 4

ACROSS

1 Re-arranged drop-in almost becomes hearing test (3,4)
5 Volume descriptor begins with tiff (7)
9 Imp ends up pinching off tubing (5)
12 Expose, as of reactor core (7)
13 Charity event outweighs risk, one hopes (7)
14 Groan gives rise to unreactive gas (5)
15 Do good things to ore? (11)
16 Loose pharmaceutical company (5)
17 Acknowledges origin but consumed by attrition (11)
20 Graphite and diamond greet figure of speech by handout of rope (9)
21 Enigmatic French resembles moisture separator (2,7)
22 Spread around, probably by Gauss (I I)
25 Agent may be telephonic or mathematical (8)
28 Retirement funds and lodgings (8)
32 I divide persons to produce wide scattering (11)
33 Served before spaghetti (9)
36 Change courtesy of Laplace (9)
38 Regular shaking concluded rational (11)
39 Old sap catches women and flies (5)
40 Disadvantageous, despite mental finale (11)
44 Viewed differently, peaks become eloquent (5)
45 Twisted French tin swallowed by me in the morning (7)
46 French management? Could be it's gone (7)
47 Power unit (5)
48 Aster uses my ends to gain command (7)
49 Useful form of UO_2 (7)

Solution on page 44

DOWN

1 True vertical given by Latin lead (5)
2 Nuclear company in recent swindle (5)
3 Concerning high frequencies-abbr (5)
4 Golden when used by descending executives (9)
5 Sailor who also makes sandwiches? (10)
6 Like a Christmas stripper (2,4,4)
7 Due for salary increase (2,3,5)
8 Oxymoronically oversized (6,5)
9 Former radio repair operation (6,5)
10 Vulgar expression for ornithologist in trouble? (2,5)
11 Oxford mathematician, or neeps perhaps (7)
17 Humanlike, and French king comes to Freudian conclusion (7)
18 Possessed by redheads and steels (7)
19 Complements ands and buts (3)
23 Transform moths on symphony hall (7)
24 Whisky production makes little Diane immobile (7)
26 Scottish picketer? (1,3,6)
27 Exclamation describes ideal plant functioning (2,2,7)
29 Expresses fate or slum otherwise (10)
30 Given under oath (2,8)
31 Galvanic cell based on sodium and sulphur-abbr (3,7)
34 Bargaining to new heights at the post (7,2)
35 Interaction between UO_2 and cladding abbr (3)
36 Toms ran in confusion to back of boat (7)
37 Surroundings suggest I am bent (7)
41 A Ford, synonymous with failure (5)
42 Brief moment ends coldly (5)
43 Associated with sausages and golf (5)

AMERICA THE POWERLESS: facing our nuclear energy dilemma

Reviewed by Fred Boyd

by Alan Waltar, with a foreword by Dr. Glen Seaborg
Cogito Books, Madison, Wisconsin, ISBN 0-944838-58-8

For those who experienced Alan Waltar's impassioned talk at the 50th anniversary celebration in Chalk River last summer the tone and thrust of this book will be of no surprise. It is a spirited argument for nuclear science and technology presented in an easy to read and often humorous style which is enhanced by cartoon illustrations by Kathy Kachele.

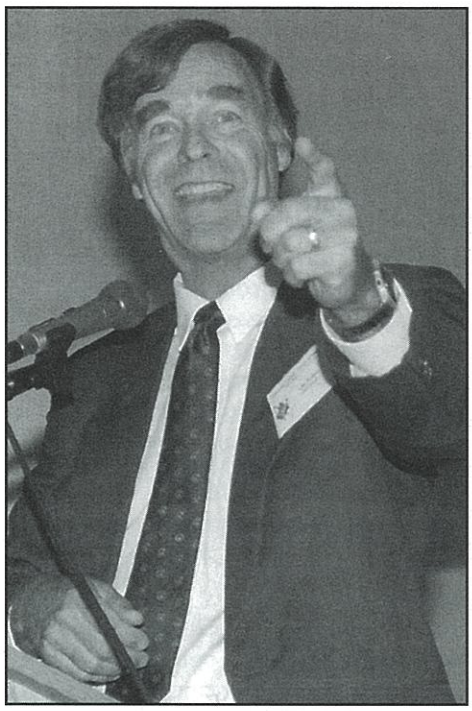
In his foreword Nobel laureate Dr. Seaborg says: *I believe that the stalemate in nuclear energy is the result of poor communication between the scientists and engineers and the community at large. .. Dr. Waltar is more than a competent scientist. He is an effective communicator. .. He presents an honest , authoritative, yet delightfully readable, response to [the] concerns [about] nuclear energy that trouble most Americans.*

Waltar begins each chapter with a position that is typical of those sceptical about nuclear energy and then presents a clear and straight forward response. Some of the chapter headings are:

- Radiation - the invisible enigma;
- After Chernobyl? You've got to be kidding!
- Not in my backyard.

While the context is obviously that of the USA the topics are universal.

This would be a very useful book for anyone engaged in communicating with the public.



Alan Waltar at the 50th anniversary celebration in Chalk River, August 1995.

SILICON SNAKE OIL: Second Thoughts on the Information Highway

Reviewed by Keith Weaver

by Clifford Stoll
Doubleday, New York, April 1995

If you are like me, you are by now sick to death of hearing about the information superhighway. What will it do? Hard to tell. Everything, it seems. Even more than everything. What is it? Once again, difficult to say. But it seems to be a souped up toll road that follows the Old Buzzword Trail, and leads from, well, "here" to, well, I guess "there". As you all know, the Old Buzzword Trail starts off at High-Tech Junction, winds through Buzzword City, and then skirts the edge of Buzzword Gulch before climbing the dizzying heights of Buzzword Pass. From the top, one can finally see it: the Promised Bland.

Silicon Snake Oil calls a long overdue time-out. If you want a superb example of what is meant by another buzzword, "reality check", this is it. Silicon Snake Oil gives you the ultimate reality check. Here is a book that is natural, relaxed, humane, level-headed, hilarious, thought-provoking and even poetic, a refreshing blast of constructive skepticism. It is a warning, by an Internet user, of what the online future is and what it is not, what it can do and what it cannot. (Along the way, Stoll describes a useful method for nailing jello to the wall.)

continued on page 44

Clifford Stoll is an astronomer with an interest in the atmosphere of Jupiter. He owns five computers and has spent a lot of time online. He is concerned that the grotesque over-selling of the Internet and the online future is warping people's image of reality already. Sure, the Internet has interesting possibilities, and the virtual reality capabilities of software are formidable. But what is not even included in the fine print is a warning of what the online future is not. Yes, it is a networked neighbourhood, and the files one picks up on it came from real people. But it is also "an unreal universe, a soluble tissue of nothingness. While the Internet beckons brightly, seductively flashing an icon of knowledge-as-power, this nonplace lures us to surrender our time on earth. A poor substitute it is, this virtual reality where frustration is legion and where - in the holy names of Education and progress - important aspects of human interactions are relentlessly devalued."

An important concept to have in mind, when dealing with rabidly optimistic computer nerds is "bogosity". The instrument used to measure bogosity is the "bogometer". A bogometer tells you to what extent something is bogus. For many important applications, you will have to switch your bogometer to its highest range. Two such applications are the hopeful and utopian uses of computers in education and in libraries. Both of these are dealt with in excellent fashion by Stoll.

Computers, so the hucksters tell us, will remove the drudgery, the tough slog from learning; teachers will become simply brokers, "connecting our students to others across the nets who will help them create and add to their knowledge". (Do you get a wonderful image of happy peasants singing and dancing in the sunshine? The needle of your bogometer should be straining mightily against its top-scale end peg.) Similarly, it is said that libraries will become extinct once their contents are available electronically. (My bogometer is now making a funny noise; the needle is quivering and wisps of black smoke are coming from somewhere at the back.) How are all those books going to be digitized? Who is going to pay for it? (The cost might be something like a hundred dollars each. There are millions of them.) How are we going to store that material? CD-Roms? A caution from Stoll.

"Think of the many extinct [storage] formats: 78-rpm records; 2-inch quad-scan videotape; phonograph cylinders; paper tape; 80-column punch cards; 100-column punch cards; 7-track digital tape; reel-to-reel audio tape; 8-track tapes; DECTape; 8-millimeter movies; 5-inch glass lantern slides.

"Think of the formats that are disappearing today: 45- and 33-rpm vinyl records, 5.25-inch floppy disks; Betamax tapes; single-side, single-density diskettes; EBCDIC coding."

How long will the equipment to read today's formats remain current?

"'Aah', you're saying,' just replicate the digital information onto a more modern format'. A good solution, though quite expensive. Every twenty or thirty years, an entire collection will have to be duplicated." . . . "Libraries don't have the money or the expertise to constantly replicate their collections."

Perhaps computers and digital technology will invade libraries even to a greater extent than they have today, but Stoll's prediction of the result is probably closer to the likely outcome than is that envisaged by the soothsayers. Computers will eat into book and periodical budgets, and steal librarians' time from the users. "The result won't be a library without books - it'll be a library without value."

There is so much valuable observation in this book, compressed into thirteen chapters of staccato presentation, that the only recommendation one could make is "Read it!" The author has produced a powerful and sane social commentary on an icon of our times. He has also served up a cold water antidote to the hyperventilated but shallow enthusiasms of its worst flatland promoters. I can do no better than conclude with his own conclusion.

"The popular mythos tells us that networks are powerful, global, fast and inexpensive. It's the place to meet friends and carry on business. There, you'll find entertainment, expertise and education. In short, it's important to be online.

"It ain't necessarily so.

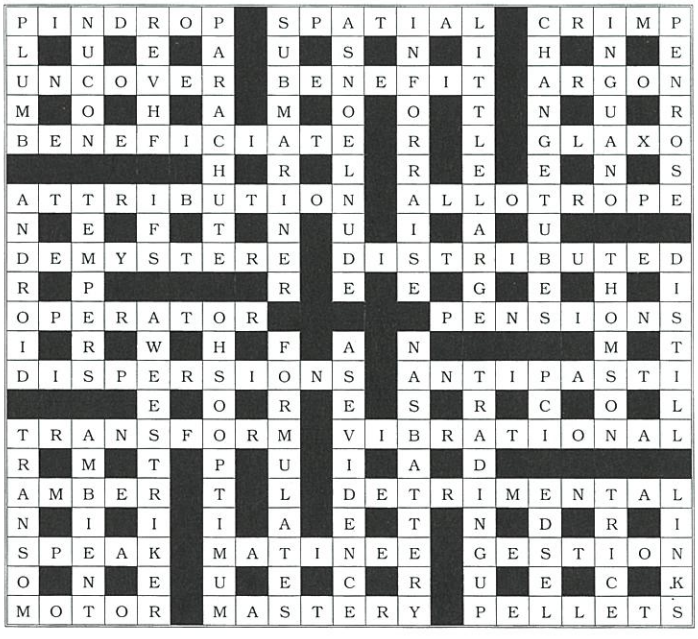
"Our networks can be frustrating, expensive, unreliable connections that get in the way of useful work. It is an over-promoted, hollow world, devoid of warmth and human kindness.

"The heavily promoted information infrastructure addresses few social needs or business concerns. At the same time, it directly threatens precious parts of our society, including schools, libraries and social institutions.

"No birds sing.

"For all the promises of virtual communities, it's more important to live a real life in a real neighbourhood."

Solution to Crossword on page 42



CALENDAR

1996

March 4 - 6

Fusion Safety Seminar
Toronto, ON
contact: Julie Moir
CFFTP
Mississauga, ON
Tel: 905-855-4701
Fax: 905-823-8020

March 10 - 14

ASME/JSME ICONE-4
Louisana, USA
contact: Dr. Howard Chung
Argonne National Laboratory
Chicago, IL
Tel: 708-252-6159
Fax: 708-252-4780

March 15 - 16

CNA/CNS Student Conference
Ottawa, ON
contact: Mohammed Lamari
Carleton University
Ottawa, ON
Tel: 613-520-2600 ext 1760
Fax: 613-520-5715
e-mail:
mlamori @ ccs.carleton.ca

March 25 - 29

Nuclear Industry Exhibition
Beijing, China
contact: Xu Honggui
Chinese Nuclear Society
Beijing, China
Fax: 86-1-852-7188

April 8 - 12

IAEA Conference: One Decade After Chernobyl
Vienna, Austria
contact: IAEA Conf. Section
Vienna, Austria
Tel: 43-1-2060-21310
Fax: 43-1-20607

April 11 - 12

KAIF/KNS Annual Conference
Seoul, Korea
contact: KAIF
Seoul, Korea
Fax: 82-2785-3975

April 14 - 17

ANS Topical Meeting - Decontamination & Decommissioning
Chicago, Illinois
contact: Donald Eggett
Commonwealth Edison
Downers Grove, Ill.
Tel: 708-663-7216

April 21 - 25

ANS Topical Meeting Radiation Protection and Shielding
North Falmouth, Mass.
contact: Richard Cacciapouti
Yankee Atomic Electric Co.
Boston, Mass.
Tel: 508-779-6711
Fax: 508-568-3700

April 27 - May 3

Electricity '96, CEA Conference and Exposition
Montréal, Québec
Special session on nuclear, May 1
contact: Neil Craik
Fredericton, N.B.
Tel. 506-454-0274
Fax 506-454-8455

May 6 - 9

ANS Topical Meeting on Nuclear Plant I and C and Human-Machine Interface
University Park, PA
contact: Dr. R.M. Edwards
Penn State University
Tel: 814-865-0037
Fax: 814-865-8499

May 13 - 14

Conference on CANDU Fuel Handling
Toronto, ON
contact: Ron Mansfield
Mississauga, ON
Tel/Fax: 905-823-2624

May 14 - 17

International Conference on Non-Proliferation and Safeguards of Nuclear Materials in Russia
Moscow, Russia
contact: Sergei Kushnarev
Kurchatov Institute
Moscow, Russia
Fax: No. 7 - 095-196-2073

May 15

KAIF/CNA CANDU Seminar
Seoul, Korea
contact: J. Richman
CNA
Toronto, ON
Tel: 416-977-6152
Fax: 416-979-8356

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June 9 - 12

CNA/CNS Annual Conference
Fredericton, New Brunswick
contact: Sylvie Caron
CNA/CNS office
Toronto, ON
Tel: 416-977-6152 ext18
Fax: 416-979-8356

June 9 - 12

Canadian Radiation Protection Association Annual Meeting
Trois Rivières, PQ
contact: Michel Rhéaume
Centrale Nuclieare Gentilly
Gentilly, PQ
Tel: 819-298-5252
Fax: 819-298-5039

June 16 - 20

ANS Annual Meeting
Reno, Nevada
contact: ANS
La Grauge Park, Illinois
Tel: 708-579-8258
Fax: 708-352-0499

July 21 - 26

ASME Pressure Vessel Conference
Montreal, PQ
contact: Dr. R.C. Gwaltney
Oak Ridge National Lab.
Oak Ridge, TN
Fax: 615-574-0740
e-mail: rcg@ornl.gov

August 18 - 24

SPECTRUM '96 – ANS International Topical Meeting on Nuclear and Hazardous Waste Management
Seattle, WA
contact: K.L. Skelly
Richland, WA
Tel: 509-376-3931
Fax: 509-372-3777

September 8 - 11

5th International Conference on Simulation Methods in Nuclear Engineering
Montréal, Québec
contact: J. Saroudis
AECL Montreal
Tel: 514-871-1116
Fax: 514-934-1322

September 16 - 19

Deep Geologic Disposal of Radioactive Waste
Winnipeg, MB
contact: M.M. Ohta
AECL Research
WL Pinawa, Manitoba
Tel: 204-345-8625 ext 201
Fax: 204-345-8868
e-mail: ohta@wl.aecl.ca

September 17 - 20

IAEA Specialists Meeting on Experience and Improvements in Advanced Alarm Annunciation Systems
Chalk River, ON
contact: L.R. Lupton
AECL - CRL
Tel: 613-584-8811 ext. 3433
Fax: 613-584-9541
e-mail: luptonl@crl.aecl.ca

September 29 - October 2

Canadian Society for Chemical Engineering Annual Conference
Kingston, ON
contact: Dr. H.W. Bonin
RMC
Kingston, ON
Tel: 613-541-6613
Fax: 613-542-9489

September 30 - October 2

Economic Nuclear Power for the 21st Century
Paris, France
contact: TOPNUX '96
Société Francoise d'Energie Nucléaire
Tel: 33.1.44.19.62.16
Fax 33.1.44.19.62.22

October 7 - 9

Yugoslav Nuclear Society Conference
Belgrade, Yugoslavia
contact: Radojko Pavlovic
Belgrade
Fax ++ 381-11-455943

October 20 - 25

10th Pacific Basin Nuclear Confernece
Kobe, Japan
contact: 10-PBNC
Atomic Energy Society of Japan
Tokyo, Japan
Fax: 81-3-3581-6128

October 27 - 31

General Conference on Nuclear Energy
Rio de Janeiro, Brazil
contact: Everton de Almeida Carvalho
Brazil Nuclear Energy Assoc.
Rio de Janeiro, Brazil
Fax 55-21-541-8785

November 10 - 15

ANS/ENS International Meeting
Washington, D.C.
contact: ANS
Le Grange Park, Illinois
Tel: 708-579-8258
Fax: 708-352-0499

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1996 *continued*

November 17 - 22 — **ASME International Mechanical Engineering Congress**
Atlanta, Georgia
- Symposium on Inelastic Methods for Structural Analysis and Design

contact: Robert Sammataro
Electric Boat Div.,
General Dynamics
Groton, Conn.
Tel: 860-433-3904
Fax: 860-433-3157

- Session on Exp:l Study of Multiphase Flow

contact: Dr. B.W. Yang
Columbia University
New York, NY
Tel: 212-280-4163
Fax: 212-678-5279

1997

March 23 - 26 — **Advances in Fuel Management**
Myrtle Beach, SC
contact: Dr. Paul Turinsky
North Carolina State Univ.
Rawleigh, NC
Fax: 919-515-5115
e-mail: turinsky@eos.ncsu.edu

April 14 - 18 — **5th International Topical Meeting on Nuclear Thermal Hydraulics, Operations and Safety**
Beijing, China
contact: Ken Talbot
Bruce NGD 'A'
Tiverton, ON
Tel: 519-361-2673

June 1 - 4 — **2nd International Topical Meeting on Advanced Reactors Safety**
Orlando, Florida
contact: Dr. Rusi Taleyarkhan
Oak Ridge National Lab.
Oak Ridge, Tenn.
Tel: 423-576-4735
Fax: 423-574-0740
e-mail:
zrt@cosmaill.ornl.gov

June 8 - 11 — **CNA/CNS Annual Conference**
Toronto, ON
contact: Sylvie Carson
CNA/CNS
Toronto, ON
Tel: 416-977-6152 ext 18
Fax: 416-979-8356

August 17 - 21 — **International Conference on Neutron Scattering**
Toronto, ON
contact: Dr. W.B.L. Buyers
AECL Chalk River Lab.
Chalk River, ON
Tel: 613-584-3311
Fax: 613-584-1849

September ? ? — **5th International CANDU Fuel Conference**
Toronto, ON
contact: Dr. J. Lan
AECL - SP
Tel: 905-823-9040

October 6 - 10 — **International Conference on Mathematical Methods and Supercomputing for Nuclear Applications**
Saratoga Springs, NY
contact: Dr. M.R. Mendelson
Tel: 518-395-7046

November ? ? — **4th CANDU Maintenance Conference**
Toronto, ON
contact: Sylvie Carson
CNA/CNS
Toronto, ON
Tel: 416-977-6152 ext. 18
Fax: 416-979-8356

1998

May 3 - 8 — **11th Pacific Basin Nuclear Conference**
Banff, Alberta
contact: Ed Price
AECL Sheridan
Tel: 905-823-9040

CNS Bulletin - Numbering

To conform with the fiscal year of the Canadian Nuclear Society (which is now the calendar year) we have changed the numbering of this issue to Vol. 17. No. 1.

The four issues of Vol. 17 will be published within the fiscal/calendar year 1996.

This means that Volume 16 has just three numbers.

THE DARKER SIDE

by George Bauer

Summaries of any year just past are usually fairly turgid, predictable affairs. Whereas the year itself, as it was passing, is generally taken not too seriously, once it is over a kind of presbyterian cloud descends upon all prospective commentators. Everything becomes fair game: how many times Agnes Bishop had porridge during the year, and whether that correlates with Ottawa's road repair budget; Maurice Strong's taste in socks and whether that spelled the end as far as Mike Harris was concerned; the extent of Mike Harris' collection of Willie Nelson and Garth Brooks, and whether he really did acquire this taste from Bob Rae; why the parsnips were all so bitter last year.

It wouldn't be so bad if there was the odd snippet of important stuff interleaved somewhere amid all the dross. Not sure what I'm getting at? Consider a few items from years past.

Prior to 1979, the great unwashed would probably have considered a "relief valve" to be an item of bathroom plumbing and a topic not to be broached either in polite company or at cocktail parties. Note that the two are not synonymous. After Three Mile Island, all that changed. People were soon discussing polisher performance, feedwater pumps, steam generator dryout times, core melt sequences, and, yes, relief valve reliability with all the sonorous assurance of veteran nuclear industry PR types. (Paradoxically, the former group somehow managed to achieve some credibility where the latter were viewed as quaintly anachronistic irrelevancies, much as one would now regard pet rocks or house-trained ducks.) Cinematophiles, and others of the intellectually challenged crowd were still talking in terms of meltdowns (strictly speaking, meltsdown), China Syndrome events and quoting Jane Fonda complete with grammatical atrocities. There was little publicity given to the fact that over a quarter of the world's population feared not a China Syndrome, but a Patagonia Syndrome.

A second example dates from the Challenger explosion ten years ago. Throughout 1986, O-rings were on everyone's lips. Once again, from that time onwards, casual eavesdropping next to the water cooler would make one party to discussions of pitch and yaw, of max Q, of blow-by, of tolerable flexing in booster segments, of gimbal tolerances and of William Rogers. Everyone had a cousin who worked at Morton Thiokol. Now, ten years later, there is renewed chatter involving "normal" accidents, homeostatic risk, and how complexity and chaos are removing us yet further from our Golden Age.

As a third and final example, consider the recent collapse of Barings Bank. Within hours of that event the babblers leapt into action and the rubber chicken circuit was soon alive with pronouncements on international finance, the state of the world banking system, inside accounts of the shady practices of traders. Advice on derivatives, Sicilian bond yields, South American mutual funds, rhenium speculation, what to watch for on NASDAQ, rainforest futures and the role of cash in everyday life, was on offer at any street corner. Record numbers of people could be found reading the *Report on Business* on subway trains, and tut-tutting with all the subdued alarm of conservative bankers. Sales of "Our Mutual Friend" roared skywards. You became "Nobody" if the world learned that you did not have a self-directed RRSP. These sorts of topics, and much more, made the rounds while everyone waited for the next diverting crisis.

These three examples illustrate the noise that serves to conceal the signal. What is the signal, those significant jewels lost in all the warbling?

It would be insulting to the seasoned readers of this onomastical gazette simply to trot out some dull list of factoids in an attempt to counteract the influence of an even duller list of past babblings. So instead, I will try to pick out a few of those significant events of 1995 that one often has to search for in the shadows.

In February, an international conference of technical specialists was convened in Ajax. It was not reported because the editor of the ***Ajax Warrior*** suffered a flare-up of his hemhorroids that day. The topic was "Standard Nomenclature for Describing Operating Excursions", or in other words, "When is a LOCA not a LOCA?". The meeting was unanimous: when it happens in one of our plants.

In April, the AECB celebrated 24 consecutive months during which it had not made a single significant decision.

In May, a sharply worded communication to ***Nature*** from five renowned scientists at AECL's laboratory at Whiteshell successfully contested the claim by American scientists to have characterised the genome of *diefenbachia,* on the grounds that *diefenbachia* is not a variety of mouse.

The June issue of the ***CNS Bulletin*** contained a report that a new government had been elected in Ontario. This prompted a review by the Ontario NDP who concluded in August that the report was correct.

Also in June, the Organisation of Hotel Patrons formed their own lobby group. It is based in Port Perry, which, significantly, has no hotels.

Ontario Hydro issued a surprise announcement in September that it had purchased Peru and Costa Rica. Ontario's Premier expressed his satisfaction that the utility was diversifying and expanding its holdings in private sector companies, especially ones with such exotic names.

In October, Quebec decided not to do anything just yet, and certainly not until AECL removed its presence from Montreal.

In December, Jeanne Dixon predicted that next year would be a leap year, and would carry the designation "1996". This brought panic to the AECB, and a rush reprinting of their corporate calendars, since they had misunderstood the meaning of the term "leap year".

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