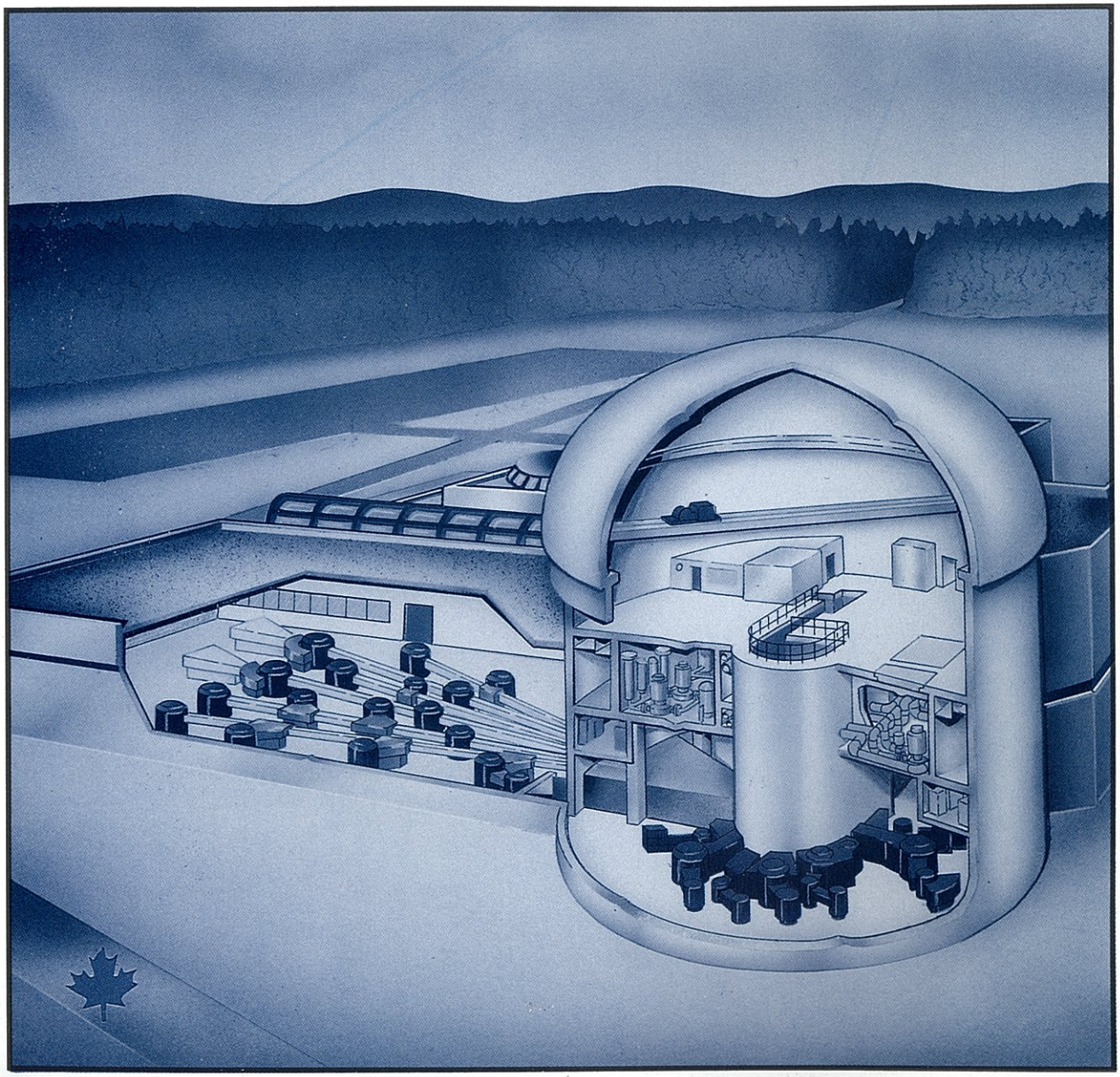
CANADIAN NUCLEAR SOCIETY

bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

Spring / Le printemps 1995 Vol. 16, No. 1



- Siting ITER
- A possible new IRF
- Nuclear Safety Convention
- US nuclear program
- CNA/CNS Student Conference
- The AECB Audit

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Cover illustration

The cover illustration is an artist's rendition of the Irradiation Research Facility proposed by AECL. See article on page 6. *(Illustration courtesy of AECL)*

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ISSN 0714-7074

The *Bulletin of the Canadian Nuclear Society* is published by the Canadian Nuclear Society; 144 Front Street West, Suite 725; Toronto, Ontario; Canada; M5J 2L7.
(Telephone (416) 977-7620; FAX (416) 979-8356)

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

CNS provides Canadians interested in nuclear energy with a forum for technical discussion. For membership information, contact the CNS office, a member of the Council, or local branch executive. Membership fee is $55.00 annually, $30.00 to retirees, $20.00 to students.

La SNC procure aux Canadiens intéressés à l'énergie nucléaire un forum où ils peuvent participer à des discussions de nature technique. Pour tous renseignements concernant les inscriptions, veuillez bien entrer en contact avec le bureau de la SNC, les membres du Conseil ou les responsables locaux. La cotisation annuelle est de 55.00 $, 30.00 $ pour les retraités, et 20.00 $ pour les étudiants.

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Printed by The Vincent Press, Peterborough, ON

EDITORIAL

Combined Effort Needed

For those of us who wish to see the logical application of science and technology for the betterment of the world it can be frustrating to realize that major scientific projects are almost always decided on non-technical grounds.

Take, for instance, the two projects outlined in this issue – the possible siting of the large fusion machine ITER in Canada, and the building of a badly needed Irradiation Research Facility. If either of these go ahead it will undoubtedly be on the basis of political factors, perhaps couched in some economic jargon which will have little foundation.

It is essential that we accept this as a way of our society and learn to live with it. That does not mean ignoring science and technology. The scientific and technical basis and justification for any such project must be well and soundly established. That is necessary but not sufficient. Once that has been done the focus can and must turn to the political, societal questions.

In our society, if government backing is desired it is essential to have public support, or, at the very least, no public opposition. (Apathy has its virtues.) Unfortunately, things scientific and technical are not high in the interests of most people. This is despite the fact that we are impacted by the products of science and technical in almost every aspect of our lives.

The scientific and technical community has failed to demonstrate to the public at large that it is the products science and technology that make modern life as comfortable as it is. The average person lives better today than kings did centuries ago.

We need to band together with all other scientific and technical societies to develop programs to educate the young and to convince the public that the products of science and technology are not evil but are beneficial and desirable. This is a large and challenging task. No one society can do it alone.

In This Issue

Unlike the previous issue of the *CNS Bulletin* this one does not have a single theme or emphasis. Instead it is somewhat of an eclectic mixture of papers and articles, at least some of which we hope will be of interest to readers.

Two of the articles deal with what might be – **Prospects for Siting ITER,** on the intriguing possibility of having the next large fusion machine built in Canada, and, **A New Irradiation Research Facility,** describing AECL's proposal for a new high flux reactor.

There is an interesting look at our neighbour's nuclear program in **A View of the Nuclear Program in the USA**, by John Graham, president-elect of the American Nuclear Society (and one-time member of AECL).

Egon Frech, formerly of AECL Research and now living in Washington, D.C., outlines how professionals and the public differ in their views of risk in, **The Risk Perception Gap.**

A brief article, **Classifying Nuclear Events**, reports on the lack of a common terminology in Canada for describing nuclear accidents despite the existence of a widely accepted international system, the International Nuclear Event Scale.

A report is included on the successful **20th CNA/CNS Student Conference** which was held in Winnipeg in March, along with abstracts of the winning papers. It is unfortunate that we were not able to print the full papers as they are impressive.

The solutions to the inaugural **crossword puzzles** in the last issue are included along with new puzzles to challenge you.

Again, we have the "**back page**" by the irrepressible (nom-de-plume) George Bauer.

And, of course, there is news of the Society and a smattering of other information which may or may not be of interest.

Our thanks to the many contributors – the *CNS Bulletin* could not exist without them.

Deadline for Summer Issue

Please forward all submissions to the editor no later than **June 30, 1995** so that production may begin on the Summer Issue of CNS *Bulletin* in July

Pickering Incident Not "Frightening"

The Editor:

I dispute your description of the event at Pickering Unit 2 on December 10, 1994, as "frightening." You've been reading too many anti-nuclear diatribes! The event certainly does not deserve the appelation "frightening," in that the effectiveness of the defence-in-depth principle was once more demonstrated. Following the initiating event, systems functioned as designed and when chattering of the RV5 relief valve led to rupture of the elbow in its inlet line, the emergency coolant injection system initiated automatically, as it was designed to do in the case of such a LOCA. Finally, the operators ended the event by manually closing the liquid relief valves.

Thus, in spite of the failure of the LRV diaphragm and the design errors that led to the elbow rupture, the reactor was shut down, the fuel remained well cooled and there was no release of radioactivity within or from containment.

An assessment of the event according to the classification of the International Nuclear Event Scale (INES) shows that it should be probably classified as a Level-2 Incident (on an event scale from Level-0, no safety significance, to Level-7, major accident), even though there was no significant spread of contamination or over-exposure of a worker, which are criteria for classification as a Level-2 incident. Such classification provides a better perspective on the event than terming it "frightening."

I was disappointed that both Ontario Hydro and the AECB made no use, to my knowledge, of the INES in the short-term aftermath of the event to inform the public and the media and to help allay public fears, the main purpose for which it was developed. Although public reaction was not very strong and soon died away in this case, an opportunity was lost to educate the public and the media and, by making the INES Scale more familiar, provide the basis for better understanding of nuclear events in the future.

Perhaps no use of the INES was made in the short term because of its general lack of familiarity to the nuclear community. It might be useful for the CNS *Bulletin* to print a short article on the INES.

Dr. J.T. Rogers
Carleton University

***Ed. Note:** Despite Dr. Rogers' cogent argument we continue to feel that when failure of one component of one piece of equipment can result in the need for emergency coolant injection it is "frightening." On his point of the INES we are responding to his suggestion with an article in this issue of the CNS* Bulletin.

Prospects for siting ITER in Canada

by SHAYNE SMITH[1]

***Ed. Note:** A move is underway to have the International Thermonuclear Experimental Reactor (ITER) located in Canada. In the following article Shayne Smith, one of the active participants, outlines some aspects of this activity and the potential benefits to Canada.*

At the CNS/CNA Winter Seminar held in Ottawa on February 7, 1995, Dr. Don Dautovich, of the Canadian Fusion Fuels Technology Project (CFFTP), outlined Canada's potential role in hosting the International Thermonuclear Experimental Reactor (ITER) project.

Currently being designed by an international community of scientist and engineers, ITER represents the next step in fusion energy research. The purpose of the project is to demonstrate the engineering feasibility of fusion energy. ITER is the final step before a power producing commercial prototype can be developed. CFFTP, an agency funded jointly by Ontario Hydro and the federal government, is making an innovative proposal in which Ontario Hydro would provide space at its Darlington or Bruce nuclear sites as potential sites for the ITER project.

Dr. Dautovich stated that "the project represents thousands of jobs and billions of dollars for Ontario and the region," and that the ITER project "will become a showcase for one of the world's most advanced energy technologies". The results from a recent economic impact analysis, conducted by Ernst & Young, were summarized to show the potential benefits to Canada from hosting ITER.

To pursue the siting effort an organizational structure has been formed comprising a Siting Task Group, and a Siting Board to provide executive direction and input. These groups, which include representatives from private industry, universities, local municipalities, labour, government, and Ontario Hydro, will assess Canadian options and evaluate the merits of a Canadian site.

Over the next several months, they will conduct discussions with Canadian officials and with members of the international ITER parties to determine the best course of action for Canada. The goal will be to seek support from both the federal and provincial governments, and to gain public support and acceptance to further pursue this venture.

ITER is a joint project of the European Union, Japan, USA and Russia. Its objective is to demonstrate that an ignited, self-sustaining fusion reaction can be produced in a practical machine. Canada has been involved as a partner of the European Union.

Research and experimentation on nuclear fusion has been underway for decades with hopes of someday being able to harness its potential as a clean, safe and reliable energy source for the future. Most of this research has been with "tokamak" machines. (See sidebar).

Fusion has been demonstrated within a superhot gas mixture which is confined by strong magnetic fields inside a containment structure. Unlike the nuclear fission process that occurs within present-day nuclear reactors, hydrogen isotopes (deuterium and tritium) are joined or "fused", a process which results in a large release of energy.

Unlike fission, the fusion process is not spontaneous. In the event of a loss of control, the reaction stops. However, a large amount of energy is produced from a small amount of fusion fuel. The energy released by only 1/2 ton of fuel is equivalent to 150 tons of uranium consumed in a CANDU reactor, or 2 million tons of coal consumed at a fossil fuel generating station.

Approximately $2 billion is currently spent annually in the worldwide fusion R&D effort. ITER is the most significant international. Begun in 1988, the ITER project is now at the engineering design stage. The project represents a $20 billion R&D program over its planned 30-year lifetime. Before finalizing many of the design details a site must be chosen for the facility over the period 1995-1997.

Through its National Fusion Program, Canada has been a contributor to the ITER design effort in participation with the European Union. Canada's contributions have been in the research, development and design of tritium and remote handling systems, employing Canadian expertise developed in the CANDU nuclear program and in the Canadian Space Station Program. These efforts have involved a broad cross-section of high-tech industries and university departments across Canada.

Both Ontario Hydro and Atomic Energy of Canada Ltd. have been key supporters in the development of the Canadian fusion program. Because CANDU reactors generate tritium as a by-product, the international fusion community has welcomed Canadian experience in this regard, particularly with respect to tritium handling and processing, safety and licensing issues, and in plant layout, planning and estimation.

From the international perspective, Canada has several attributes as a host for ITER:

- the Bruce and Darlington sites are located on the Great Lakes, making them easily accessible by

[1] Shayne Smith is a principal of Wardrop Engineering Inc. and a member of the ITER Siting Task Group. He is also a member of the CNS Council and former chairman of the CNS Fusion Committee.

countries wishing to ship prefabricated components to the site.

- the existing nuclear regulatory system in Canada can accommodate the licensing of ITER. Other countries may have to develop new legislation.
- Ontario Hydro removes tritium as a by-product from CANDU reactors and now possesses the largest non-military supply of this valuable commodity. Tritium currently sells for $30,000 per gram. ITER could require 100 kg.
- Canada is highly rated as a place to live. International research staff would welcome the opportunity to live at a Canadian ITER site.

The potential to host the ITER site, and give Canada a foothold in this world-leading energy research effort is an exciting prospect. Significant economic benefits would result from the presence of a skilled international workforce that would remain in Canada for over 30 years. Ontario Hydro ratepayers would benefit by the sale of tritium, and through a long-term contract for 200 MW of electric power. Canadian industry would share in contracts to develop and maintain the site facilities and high-tech systems.

To quantify these benefits, the accounting firm, Ernst & Young, was retained to conduct a formal evaluation of the possible economic impacts resulting from the siting of ITER in Canada.

The Ernst & Young study concluded that:

- the total ITER spending in Canada during the entire 30-year project is expected to be about $8 billion. As a result, Canada would benefit from an $11.8 billion boost in Gross Domestic Product;
- the total Canadian employment created directly and indirectly by the ITER project is estimated at nearly 87,000 person-years of work;
- over the length of the ITER project, there would be an estimated increase in federal revenues of $1.6 billion, which would be considerably greater than the proposed federal government contribution to the project of $570 million.

The Ontario Hydro sites meet or exceed ITER requirements. A stable electrical supply grid, existing waste management infrastructure, an abundance of low cost power, and a skilled workforce, make Canada an attractive site prospect, and, quite possibly, the lowest cost option for the overall project. Canada is also attractive as a neutral alternative and has gained early Russian support.

There is a great deal of work to be done to develop a broad constituency of support for a Canadian ITER site. Support is needed from industry, academia, and all levels of government to improve technological activities and employment opportunities for Canadians, especially for Canada's aspiring youth.

Siting ITER in Canada would be a significant milestone in improving Canada's scientific vision. Canada is the right place for ITER, but we must convince the world.

ITER – An International Partnership

The ITER project represents a major step toward realizing the benefits of magnetic fusion energy. As a potential energy resource for the twenty-first century, fusion could meet a large part of the world's electricity needs with minimal environmental impact.

Under the auspices of the International Atomic Energy Agency, four international partners – the European Union, Russian Federation, United States and Japan – are collaborating on the design of the ITER project and the development of the required technology. Canada participates as an associate of the European Union.

From the beginning, the four partners have participated equally in all decisions about the project and have contributed equally in the areas of personnel, technology, and financial support. The ITER Council, with two government-level representatives from each of the four partner countries, is based in Moscow. It is responsible for setting policy and providing overall direction. A Technical Advisory Committee and a Management Advisory Committee provide advice to the ITER Council.

In 1987, these parties initially agreed to work together on the conceptual design activities for ITER and this stage was completed in 1990. Work has now begun on the six-year Engineering Design Activities phase which will include validating the supporting R&D work, designing the essential components, establishing site requirements, and developing detailed plans for construction, operations, maintenance and decommissioning. A decision to select a site for the project is expected in 1996.

Reporting to the Council is the ITER Project Director who supervises the Engineering Design Activities with the assistance of a Deputy Director from each partner. Each partner, in addition, has established a "home team" which performs specific research and design tasks as assigned by the Director. The Director also heads up the Joint Central Team which is responsible for integrating all contributions into a coherent design.

ITER represents an unparalleled example of international collaboration on a major scientific project and is seen as a model for other scientific projects in the future.

Tokamak

To achieve fusion the fuel (e.g. deuterium and tritium) must be heated to millions of degrees. At these temperatures the atoms in the gas collide with sufficient energy to remove their electrons. The resulting cloud of charged particles is called a plasma. The challenge is to confine the hot plasma at high density sufficently long to allow the fusion process to occur.

The primary method followed in civilian fusion research over the past four decades has been to use magnetic confinement. This method depends on the fact that electrically charged plasma particles will travel along a line of magnetic field or sppiral around it. The most successful of magnetic confinement arrangements uses a toroidal chamber surrounded by magnetic coils and was first developed in Russia in the 1950s. The word "tokamak" comes from the Russian words for toroidal chamber and magnetic coil.

The windings around the torus produce a magnetic field along the axis of the torus. A plasma current, driven by a transformer that couples energy from an external power supply, inductively heats the plasma.

The largest tokamak machine is the Joint European Torus (JET) in Culham, England. There are about 30 smaller ones, including the Tokamak de Varennes near Montreal.

Opposition to ITER

The group "Nuclear Awareness Project" based in Oshawa has produced a four-page document opposing the move to have the ITER project sited in Canada.

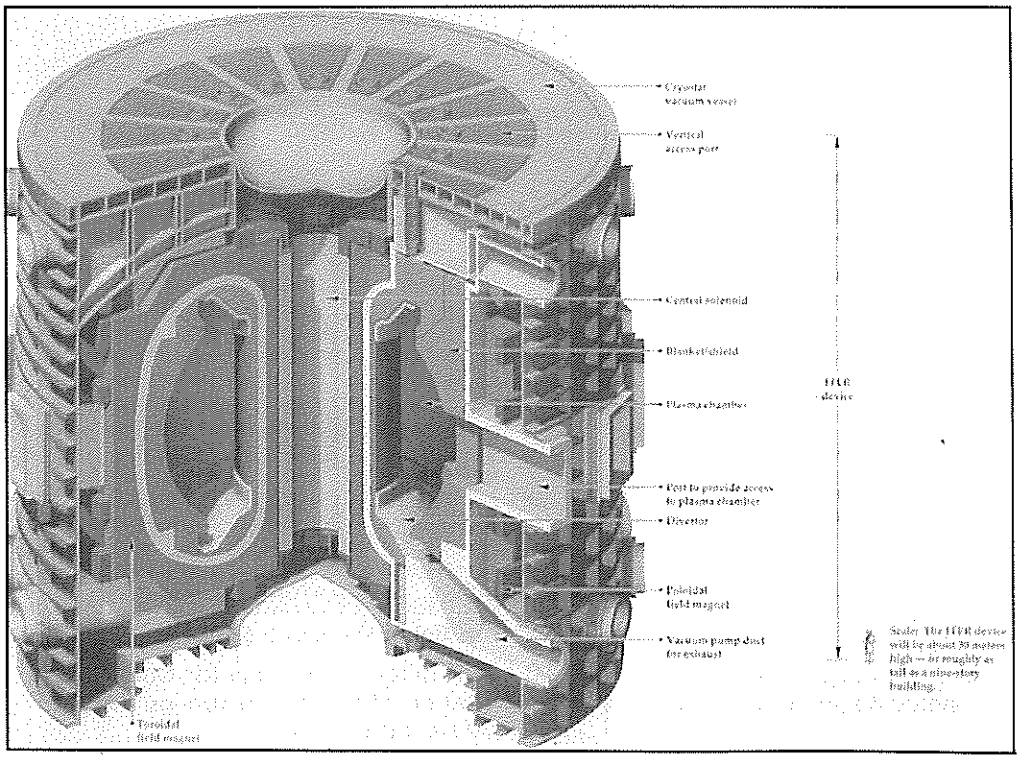
Following are some of their comments:

"The myth of fusion power is that it will be clean, safe, non-polluting, and produce virtually free energy. None of this is true. The most serious environmental problem is the use of huge quantities of radioactive tritium. Other problems include the use of lithium to "breed" tritium – lithium is a highly reactive metal that ignites spontaneously. Contrary to the popular myth, fusion does create large amounts of radioactive waste through the activation of structural materials by neutron radiation."

"A hidden cost of ITER is the capital cost of the power it will need. It is estimated that [it] will require 200 MW on a continuous basis, peaking to 1,000 MW. [This] represents a sizable investment. For example, using Darlington as a yardstick, 200 MW has a capital value of about $860 million."

"Fusion is the source of power [of the sun] [which] provides a readily available source of energy. Solar power and other renewable technologies are making significant inroads in the electricity sector. Renewable technologies are available now. Electricity generated by fusion is only high-tech fantasy that is doomed to failure."

"The sooner we end public funding for fusion research the sooner we can set ourselves on the path to a truly sustainable energy future. Let's keep fusion where it belongs – in the sun."



A computer generated conceptual drawing of ITER

A new Irradiation Research Facility?

Ed. Note: The following article is based on material provided through the office of Ian Hastings, Director, Strategic Initiatives, at AECL.

Recognizing the strategic need for neutron irradiation facilities in the future, Atomic Energy of Canada Limited has developed a concept for a new Irradiation Research Facility (IRF). Such a facility could serve a dual purpose: to test fuels and materials for existing and future CANDU nuclear power plants, and to serve as a national facility for basic materials research.

The proposal follows on a recommendation of an advisory committee to AECL's Board of Directors that "...the provision of an Irradiation research Facility at an AECL site to replace NRU be pursued with the highest possible priority."

The concept includes a research reactor, test facilities for CANDU-related research and development, experimental facilities for basic materials science, and associated laboratories, systems, equipment and buildings. The total cost of the reference IRF is estimated at $500 million (1994 dollars) assuming that it is built adjacent to an existing infrastructure for handling radioactive materials. That cost would be spread over approximately eight years.

The proposed research reactor is a 40 MW adaption of the MAPLE X-10 design, using design technology developed by AECL for the recently commissioned HANARO research reactor in Korea (previously referred to as the Korea Multi-purpose Research Reactor or KMRR), and incorporating CANDU technology. It would be a light-water pool type using low-enriched (19.7% U-235) U_3Si_2-Al fuel.

Experimental facilities would support both CANDU-related research and development and basic materials research. Those for CANDU R and D would include: horizontal fuel-test facilities, vertical fuel-test facilities, a blowdown test loop, materials irradiation facilities, hot cells. Facilities to support basic materials research include a cold neutron source, beam tubes and neutron guides.

It is recognized that, to remain competitive, CANDU technology must continue to evolve and to be improved. New fuels, materials and processes must be developed and proven in an environment simulating that inside a CANDU reactor. The NRU reactor at the Chalk River Laboratories is the only facility with this capability. However, NRU is 37 years old and is not expected to operate much beyond the year 2000.

The need for a new neutron scattering facility for basic materials research has been studied and documented by a committee sponsored by the National Science and Engineering Research Council (NSERC). As well, the Canadian Institute of Neutron Scattering has indicated that an IRF could:

- offer applications in physics, chemistry, biology, materials science and nuclear medicine;
- provide advances and economic benefit to Canadian industries;
- attract scientists from outside Canada.

A dual purpose facility would be significantly less costly than two dedicated ones. It is proposed that the IRF could be operated by AECL on behalf of a management board which would include members from both the CANDU and basic materials science constituencies.

Proposed Experimental Facilities

Horizontal Fuel Test Facilities

3 loops with test sections capable of holding several CANDU bundles each. Bottom test section replaceable with one for blowdown tests.

Vertical Fuel Test Facilities

2 test loops for multi-element partial bundles.

Blowdown Test Facility

1 BTF loop to connect to bottom horizontal test section.

Materials Irradiation Facilities

4 in-core sites with 3 or 4 inserts per site;
4 fast neutron sites with 4 inserts per site
or
1 corrosion loop per site.

Hot Cells

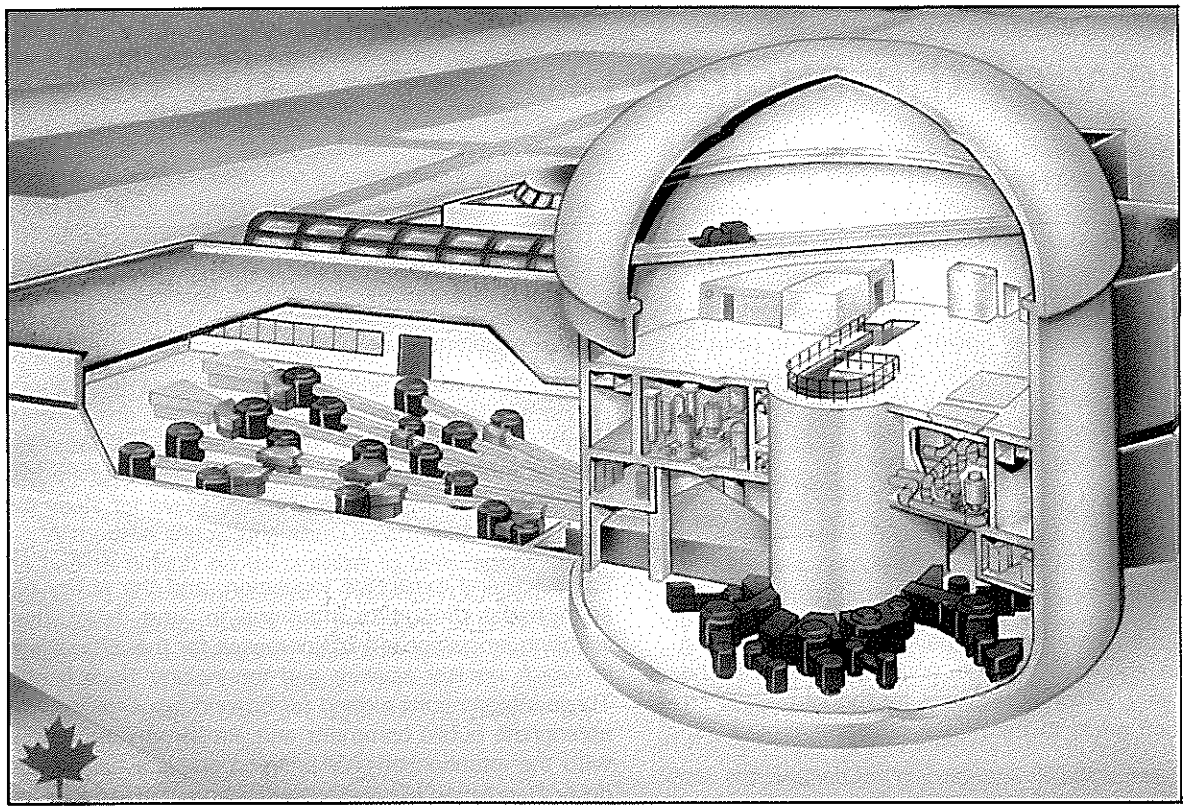
1 three-compartment cell; 1 handling cell for horizontal test sections.

Service Irradiation Facilities

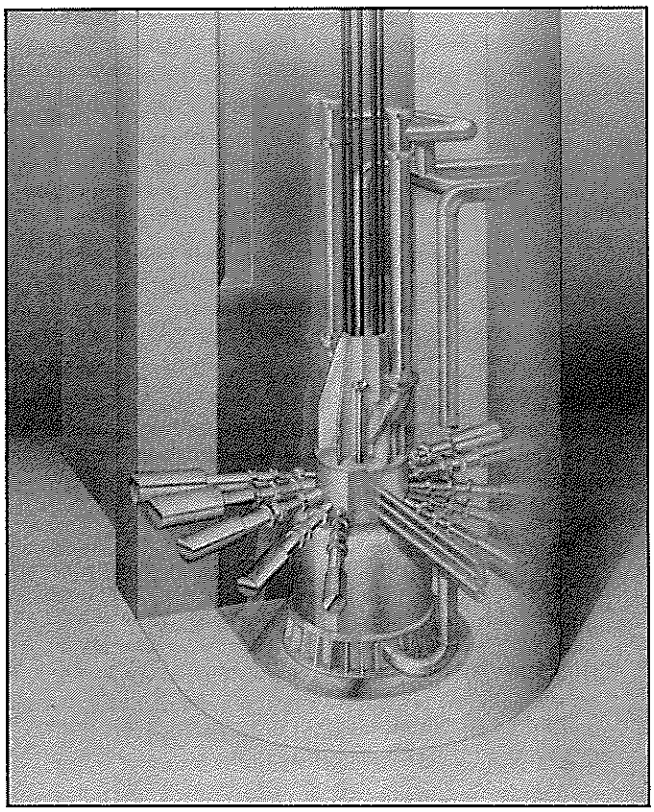
10 vertical tubes including 2 hydraulic rabbit systems; 1 pneumatic rabbit system.

Neutron Beam Research Facilities

10 beam tubes, 2 of those for Cold Neutron Source; 5 cold neutron guides; 2 thermal neutron guides.



Artist's rendition of IRF



Cutaway of IRF core

A view of the nuclear program in the USA

BY JOHN GRAHAM

Ed. Note: *John Graham is Vice President/President-elect of the American Nuclear Society. His full-time position is Vice-President, BNFL Inc., the American subsidiary of American Nuclear Fuels, and is based in Denver, Colorado. He spent a time in Canada in the 1980s as Director of Licensing for AECL Research.*

The following article is a slightly edited version of talks he gave at different gatherings in the Toronto area in late January 1995.

Headlines

Recent public declarations have painted disturbing pictures of the state of the nuclear industry in the United States, which give pause for thought.

The first refers to the power program:

"The Tennessee Valley Authority (TVA) cancels the last three nuclear plants under construction. The nuclear power program has ended and power needs are being met by small gas-powered plants and conservation programs."[1]

The second declaration, by a medical leader, the President of the Society of Nuclear Medicine, refers to his own discipline:

"The discipline of Nuclear Medicine is at a crossroads!

Nuclear medicine procedures are declining; competitive technologies are challenging the discipline; the numbers of educated and certified nuclear medicine physicians are dwindling; important nuclear medicine programs, such as the clinical applications of Photon Emission Tomography (PET), are being discontinued at major research centers."[2]

In both cases, if I were an investor, I would be looking around for prospects with greater popular support. It appears that the nuclear industry is in its death throes.

The Public

But what is public support? The Nuclear Energy Institute (NEI) regularly conducts polls of public opinion to assess the benefits of their program of advertising and education. A 1994 Gallup Poll had the following results[3]:

- 71% of the public think that it is *important* that nuclear energy should play a role in meeting America's future energy needs, and
- 57% of the public *favour the use of* nuclear energy as one of the ways to provide electricity in the U.S.

This shows good and increasing public support for the nuclear power program – if similar questions were asked of the public about non-power nuclear applications, then the support would be far greater. In fact, public support for nuclear power is good and getting better, as those 109 plants continue to operate reliably.

So – why do the headlines appear to tell a different story – apparently one of nuclear decline?

Issues

Let us consider the issues which face the nuclear industry and which directly affect the potential start-up of new plants:

Regulation

Extensive and expensive regulation, and the ability of self-interest groups to intervene in, and delay, the licensing processes is a major reason for the difficulties in which nuclear science and technology finds itself. These interventions extend far beyond responsible and appropriate public comment and are sometimes made with the intention of only bringing about a damaging delay. Regulation allows these delays and is too expensive in licensing and in operation. A compounding problem is that regulations are not risk based.

The Nuclear Regulatory Commission (NRC) regulates all nuclear activities but until recently the majority of its work has been in the power field. However, it also regulates all other applications of radiation, including medical nuclear facilities. The NRC has currently contracted with the National Academy of Science to perform a study to see whether those regulations are adequate. They could get more comprehensive and, thus, more restrictive and more expensive.

Furthermore, the Nuclear Regulatory Commission must recover all its costs from its licensees, and there is little control over how those costs are set. As an example: the NRC charge for licensing a new uranium mine was originally estimated at between $60,000 and $100,000. However, bills totalling that amount have already been received, even before an initial regulatory review of submitted material has been completed. A new estimate for licensing is set unofficially at $400,000 to $500,000.

The size and present utility of the Nuclear Regulatory Commission, as well as its consequent fees, require revision downwards.

Waste

Another issue cutting across all aspects of the nuclear endeavour is the disposal of wastes.

Low level radioactive wastes regulation is a large part of the problem though not all of it. Regulations have increased the volume of low-level wastes beyond any reasonable risk assumption (virtually clean items are sent to LLW) and the regulatory process allows the NIMBY (not in my back yard) philosophy to dominate in siting actions.

The site which is in the forefront of news is Ward

Valley in California. It has been ready to operate for many months but it is still held up in interminable studies and court actions carefully orchestrated by the intervenors.

In the power industry, the principal issue is the disposal of 'spent' fuel. The government's program is based on, first, refusing to consider reprocessing as a way of diminishing and stabilizing high level waste, and second, in confirming the acceptability of a high level repository in volcanic tuff at Yucca Mountain, Nevada. The characterization of the Yucca Mountain site is inching along slowly but the date for the receipt of 'spent' fuel assemblies is moving backwards – 17 years in the last 12. A more realistic date is now suggested to be a decade later in 2020. Thus, the date of opening a repository is moving backwards at about two years for every year of work.

Without a repository, the Department of Energy has had to default on its promise to take 'spent' fuel assemblies and is encouraging the utilities to store the fuel in dry-storage casks on the plant sites. This is being done at a number of locations and is the most likely solution to the U.S. "spent" fuel issue. An alternative solution might be a single above-ground dry storage site.

Isotopes

Currently, most of the medical isotopes in the U.S. come from Canada – from an old reactor, NRU, which has been operating for thirty-eight years. A replacement for NRU, the MAPLE-X reactor, was cancelled due to high cost, thus the reliability of the supplies of isotopic molybdenum is suspect. Presently, the U.S. has no national source or centre for the production of radioisotopes but after some pushing the Department of Energy has announced that it aims to have its own supply (of about 70% of the present Canadian output) in two years.[4] However, until some positive action takes place the U.S. medical program is based on very frail foundations.

U.S. Energy Policy

A further problem must be noted. The present U.S. administration is anti-nuclear. Official policy, published as *"Technology for a Sustainable Future"*[5] provides the official position – *"...to decrease energy use in the developed countries by means of rapid increases in energy efficiency, greater use of renewable energy sources, and increased utilization of low-emission or no-emission energy sources."*

This document does not mention nuclear power at all. Despite the fact that by replacing coal in the U.S., nuclear power is saving the release of 7 million tons of SO_2, 2.5 million tons of NO_x, and 160 million tons of CO_2 each year, the administration does not class nuclear power as a *"non-emission source of energy."*

Furthermore, by *"greater use of renewable sources"* the administration does not mean the use of reprocessing of spent fuel or the use of mixed-oxide. A paranoia against the existence of plutonium in the world exists and the U.S. Department of Energy seems bent on eliminating, first, excess weapons plutonium; next, civilian plutonium; and, finally, all nuclear materials. It is not a national policy that is based on any form of reality.

Power Prospects

A recent study for the Nuclear Electric Institute, performed for the year 1992, shows that nuclear power generates an economy within the United States of $70 billion per year and an associated 400,000 jobs.[6] That's the good news.

However, as the headline shows – we have reached the end of construction of new plants in the U.S.A. There are advanced designs on the horizon – new smaller, inherently safer, and, hopefully, less expensive designs. Some regulatory advances have been made by pre-licensing the designs, so that only those aspects relative to a specific site would need addressing and the public would get one, rather than two, opportunities to provide comment. It will streamline the public comment process and reduce the effect of self-interest groups. Yet, there can be no move towards ordering one until the need for power and electricity is great enough for the new nuclear plants to be cost-effective, until some move is made towards risk-based regulation, and until there is some restriction in the activities of self-interest groups. Current predictions are that that will not occur within the next decade.

At issue is not only the capital and operating costs of the station but also the costs of waste disposal – or long term storage – and the costs of decommissioning. The next few years will bring a greater definition to both of these budgets and they are not likely to encourage the ordering of new plants.

In such a situation there is very little forward movement. Utility owners are content to keep things moving reliably without change. Thus, there is not much support for the development of new international standards, for new training methods, or for innovative design work. Most utility owners of nuclear plants aim for operational reliability with as few changes as possible, since changes usually result in additional regulatory work and, therefore, costs.

Non-Power Prospects

A recent study for the Nuclear Electric Institute, performed for the year 1992,[7] shows that nuclear science and technology, other than power, generates an economy within the United States of $357 billion per year and an associated 3,700,000 jobs: 1,600,000 of which are directly associated with the nuclear field. The non-power nuclear industry appears to be about four and a half times as large as the power-based nuclear industry in the United States. It is probably a greater multiple in other countries. Yet, the non-power nuclear industry is something which we have tended to ignore.

Medicine

Currently, direct radiation fields and nuclear isotopes provide both research, diagnostic and therapeutic tools for the medical profession. About one in three patients hospitalized in a modern U.S. hospital will have a diagnostic procedure performed in which a radioactive tracer has an essential role – for example by following

blood flow with an external scintillation camera to track the path of technetium-99.

Patients have long been used to X-rays – now they are becoming similarly used to nuclear Magnetic Resonance Imaging (MRI) and Photon Emission Tomography (PET) – new tools for even better diagnosis of the physical and chemical abnormalities in the body.

Radiation sterilization of medical equipment is now the preferred method.

Yet, despite the value of radiation techniques, the fear of radiation has been so overplayed by the opponents of progress that some are afraid even of a life-saving medical procedure. For example, the medical community has even had to change the names of its procedures – the Nuclear Magnetic Resonance Imaging technique is called the MRI procedure, carefully avoiding the word 'nuclear'.

It is this fear of radiation which is being purveyed by anti-nuclear activists, coupled with the idea that medical low-level waste is a radioactive horror, that lies behind the headlines of nuclear medicine's potential decline. A practical problem is that, with the lack of low-level waste disposal sites, the storage of the waste on hospital property is an administrative embarrassment which is compounded by the fact that almost anything is considered to be low-level nuclear waste.

Agricultural Uses

The eradication of agricultural pests by sterilization of the males is now a widespread technique, replacing the distribution of pesticides by air. This beneficial application of nuclear science is continuing without great fanfare – principally because the public hate low-flying aircraft spraying pesticides. Irradiation techniques in the development of new strains of plants – new and virus resistant grains and with better growth and yield patterns – is an established technique principally conducted in research stations. The lack of visibility of this research protects it from the self-interest groups. Yet, these applications also suffer from the same lack of low-level waste disposal facilities.

Industrial Uses

The U.S. Consumer is generally unaware of the extensive use of radioisotopic sources in the manufacturing industry to provide process information, to measure densities of mixed fluids and solid materials, and for process quality control. Radiation tracer techniques are widely used in wear studies, in tracking flow in piping systems, in mixing fluids; and, new applications are being discovered every day. The irradiation of certain plastic material and wires to transform their properties in the manufacture of car components, furniture, plastics, and insulation, is a growth industry.

However, the lack of low-level waste disposal capability hits hard at these industrial users of nuclear technology as their capability to store the waste on their own site comes to an end. In the U.S., there are waste brokers who provide a service in treating low-level wastes, by compaction, but they have no legal ability to accept waste for longer than two years – then all wastes have to be returned to the generator in the absence of a low-level waste disposal site.

However, at times like these we seem reluctant to tell the public what they would lose if there is no low-level waste disposal capability. I believe the U.S. public is so enamoured with their automobile that they would think twice if they had to lose the robustness of the car's dashboard because the plastic could no longer be irradiated for polymerization.

Food Irradiation

The sterilization of food by irradiation is slowly gaining favour in the U.S. Opposition to the technique has been widespread but with the opening of one plant in Florida and the sale of irradiated goods across the States, progress is being made – slow but positive. Recently, there have been cases of infant deaths from the E-coli bacteria in poorly cooked fast-food hamburger meat. The danger of lack of properly prepared food by heat should help the food irradiation programs. However, at times like these the food irradiation industry has not emerged to point out the benefits of food irradiation.

Research

Biological research makes extensive use of radioactive tracers in tracking the migration of environmental species along bio-chemical pathways in the body and in nature, in investigating immunology by the transmission of materials within the body; and investigating the breakdown of pesticides – to provide a few examples. The advantage of radioactive tracers is that they can be followed by monitors external to the body rather than by invasive chemical analysis.

However, university administrators are not the researchers. They are more concerned with the administrative problem and costs of disposing of low-level radioactive wastes and the necessity for storing them on University property until a proper disposal site is opened. At Stanford University there is already pressure to abandon radioactive tracers.

Summary

The industry of nuclear science and technology *is* very much at a cross-roads.

On one hand, the U.S. nuclear power program has stopped growing and new plant orders are nowhere on the horizon – at least for ten years. On the other hand, the reliability of the operation of the existing plants, especially during adverse weather, is gaining the support of the general public. Current opinion supports the use of nuclear power despite what the anti-nuclear activists and the U.S. administration say.

On one hand the inability to dispose of low-level radioactive wastes is placing great pressure on small industries, university research departments, and the medical world, as well as the utilities. These applications have already provided great benefit to society – to the extent that the public may object strongly to doing without them. We need to show the direct connection between the destructive behaviour of self-interest groups and the loss of these benefits to society.

We, the proponents of the advantages of nuclear science and technology need to recognize that these are different days from yesterday and today may merit

changes in our approach to the public.

Lessons

Recently, an announcement that a new technique of diagnosing breast cancer through the use of a radioactive tracer, rather than by very painful biopsies, made headline news.[8] That would have been the proper occasion to note that the new procedure would also produce a little low-level waste that could be easily disposed of in an engineered landfill, and the small amount of waste generated was well worth accommodating for the benefit of the new procedure. The announcement also should have said that if low-level waste disposal facilities were not allowed to open, then this technique of discovering breast cancer probably would *not* be available and people would still have to undergo very painful biopsies – the cutting out of pieces of their flesh for testing.

Too often we have allowed our nuclear opponents to say how bad radiation is, or how bad waste is, without mentioning the benefits that accrue. It is an important responsibility of our public information system that new advances and beneficial procedures be associated with the realities of life – everything produces waste, everything has a cost, and the cost-benefit equation says that progress is worth-while. We should also note the opposite, that these advances would not be possible unless we acknowledged the small amount of waste produced and handled it properly. If we don't accept and handle the waste then we don't get the benefit. We need to bring the truth – the whole truth – to the public, to the regulators, and to the decision makers.

Notes

1. "End of nuclear road; too many safety, waste woes," USA Today, December 13, 1994.
2. Letter to James Toscas, Executive Director of the American Nuclear Society, from James J. Conway, MD, President, Society of Nuclear Medicine, November 30, 1994.
3. Gallup Poll of Nuclear Public Opinion, Nuclear Energy Institute, Washington, DC, Spring 1994.
4. *Nuclear News*, Vol. 37, No. 14, p. 17, November, 1994.
5. "Technology for a Sustainable Future – a Framework for Action," The National Science and Technology Council, presented by William Clinton and Alfred Gore, April 1994.
6. "Economic and Employment Benefits of the Use of Nuclear Energy to produce Electricity," Report prepared for the U.S. Council of Energy Awareness by Management Information Services, Inc., Washington DC, February 1994.
7. "The Untold Story: Economic and Employment Benefits of the Use of Radioactive Materials," Report prepared for Organizations United for Responsible Low-Level Radioactive Waste Solutions by Management Information Services, Inc., Washington, DC, March 1994.
8. USA Today, front page news, December 1994.

Available

Natural Analogs Video

A video depicting phenomena in nature that are analogous to processes expected to occur in the disposal of nuclear waste is available from AECL Research.

Two versions are available; one 27 minutes in length, the other 52 minutes. The shorter one is intended for a general audience while the longer one contains more technical detail.

The video deals with high grade uranium deposits such as at Cigar Lake in Saskatchewan and the Oklo deposit in Gabon in which fission occurred 2 billion years ago.

For copies of the videos or further information contact:

Donna Morrish
Nuclear Fuel Waste Management Program
AECL Research
Whiteshell Laboratories
Pinawa, Manitoba
ROE 1LO
Tel. (204) 753-2311, ext. 2387

Auditors Report on AECB

Copies of the 1994 report of the Auditor General of Canada on the Atomic Energy Control Board are available. The report reviews the organization and operation of the AECB.

It is Chapter 10 of the 1994 Report of the Auditor General to the House of Commons.

Contact: Office of the Auditor General of Canada
240 Sparks Street, Stop 10-1
Ottawa, Ontario
K1A 0G6
FAX (613) 954-0696

Environmental Modelling Text

A book on "**Watershed, River and Lake Modelling through Environmental Radioactivity**" by Dr. B. S. Shukla, has been published. The text focuses on a "3-box" model for describing the behaviour of pollutants.

It is available from:

Environmental Research & Publications Inc.
P.O. Box 79023, Garth Postal Outlet
Hamilton, Ontario L9C 7N6
Tel. (905) 385-8111

Classifying nuclear events

Ed. Note: *Prompted by the letter from Terry Rogers (see Letter to the Editor) the following short article attempts to outline the situation in Canada for classifying nuclear incidents or accidents and the International Nuclear Event Scale (INES).*

Communicating with the media and public has always been a concern of the nuclear industry. When it comes to nuclear incidents or accidents an easy to use, unambiguous system for expressing the severity of the event would facilitate early communication between organizations involved and with the public. However, in Canada there is no agreed system for classifying nuclear emergencies.

Under the Canadian constitution protection of the public is primarily a responsibility of the provinces, including responding to nuclear emergencies. Each of the provinces with nuclear power plants (New Brunswick, Ontario, Québec) have developed plans for responding to emergencies at those plants having off-site effects. These plans each have a form of classification for describing the severity of an event, but they are all different. A Federal Nuclear Emergency Response Plan (FNERP) exists but is primarily to support provincial action. It does not have a separate classification system.

Each nuclear power station has its own emergency response plan with its own classification system. In New Brunswick and Québec the provinces have adopted the "off-site" classification used by the stations. In Ontario, the four stations (Bruce "A", Bruce "B", Darlington, Pickering) have adopted the provincial classification system for "off-site" events but each has a different system for "on-site" events. The Ontario provincial system has three levels of severity.

Internationally, most countries (except Canada and the USA) have adopted the *International Nuclear Event Scale (INES)* developed in 1992 by a group of experts convened jointly by the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency (NEA) of the Organization of Economic Cooperation and Development (OECD). The objective of the INES is to provide a means for promptly communicating to the public, in consistent terms, the safety significance of events at nuclear installations. The IAEA and NEA believed that by putting events into proper perspective, the scale could facilitate a common understanding between the nuclear community, the media and the public.

The scale is designed to be applicable to events at all nuclear installations including events during the transportation of radioactive materials between those facilities. However, because of the diversity of users of radioactive sources the scale is not intended for events involving such sources.

In the INES, events are classified at seven levels. The lower ones (1-3) are termed *incidents,* while those in the upper levels (4-7) are called *accidents.* Events which have no safety significant are classified as *"below scale"* (level "0") and are termed *deviations.* Events which have no safety relevance at all are termed *"out of scale".*

The INES scale is summarized in Figure 1.

The IAEA and NEA recommend that use should be made of the *INES User's Manual* (INES: The International Nuclear Event Scale, User's Manual, International Atomic Energy Agency, Vienna, Austria, 1992) which gives detailed guidance in interpreting events and assigning them to the INES scale.

Detailed guidance is provided for events in the following nuclear installations:

- power reactors
- research reactors
- mining and milling facilities
- uranium enrichment facilities
- fuel fabrication facilities
- irradiated fuel storage and reprocessing facilities
- waste conditioning, storage and disposal facilities.

The IAEA and NEA point out that although the same scale is used for this wide range of facilities it is physically impossible for top level events (involving the release to the environment of large quantities of radioactive material) to occur at some types of installations because of the small inventory or limited amount of available energy. These could include: small research reactors, unirradiated nuclear fuel treatment facilities and most types of waste storage sites.

Figure 1: The International Nuclear Event Scale

LEVEL	DESCRIPTION	CRITERIA	EXAMPLES
ACCIDENTS 7	MAJOR ACCIDENT	• External release of a large fraction of the radioactive material in a large facility (e.g. the core of a power reactor). This would typically involve a mixture of short and long lived radioactive fission products (in quantities radiologically equivalent to more than tens of thousands of terabecquerels of iodine-131). Such a release would result in the possibility of acute health effects; delayed health effects over a wide area, possibly involving more than one country; long term, environmental consequences.	Chernobyl NPP, USSR (now in Ukraine), 1986
6	SERIOUS ACCIDENT	• External release of radioactive material (in quantities radiologically equivalent to the order of thousands to tens of thousands of terabecquerels of iodine-131). Such a release would be likely to result in full implementation of countermeasures covered by local emergency plans to limit serious health effects.	Kyshtym Reprocessing Plant, USSR (now in Russia), 1957
5	ACCIDENT WITH OFF-SITE RISK	• External release of radioactive material (in quantities radiologically equivalent to the order of hundreds to thousands of terabecquerels of iodine-131). Such a release would be likely to result in partial implementation of counter-measures covered by emergency plans to lessen the likelihood of health effects. • Severe damage to the nuclear facility. This may involve severe damage to a large fraction of the core of a power reactor, a major criticality accident or a major fire or explosion releasing large quantities of radioactivity within the installation.	Windscale Pile, UK, 1957 Three Mile Island, USA, 1979
4	ACCIDENT WITHOUT SIGNIFICANT OFF-SITE RISK	• External release of radioactivity resulting in a dose to the most exposed individual off-site of the order of a few millisieverts.* With such a release the need for off-site protective actions would be generally unlikely except possibly for local food control. • Significant damage to the nuclear facility. Such an accident might include damage to nuclear plant leading to major on-site recovery problems such as partial core melt in a power reactor and comparable events at non-reactor installations. • Irradiation of one or more workers which result in an overexposure where a high probability of early death occurs.	Windscale Reprocessing Plant, UK 1973 Saint-Laurent NPP, France, 1980 Buenos Aires Critical Assembly, Argentina, 1983
INCIDENTS 3	SERIOUS INCIDENT	• External release of radioactivity above authorized limits, resulting in a dose to the most exposed individual off the site of the order of tenths of millisievert. With such a release, off-site protective measures may not be needed. • On-site events resulting in doses to workers sufficient to cause acute health effects and/or an event resulting in a severe spread of contamination, for example a few thousand terabecquerels of activity released in a secondary containment where the material can be returned to a satisfactory storage area. • Incidents in which a further failure of safety systems could lead to accident conditions, or a situation in which safety systems would be unable to prevent an accident if certain initiators were to occur.	Vandallos NPP, Spain, 1989
2	INCIDENT	• Incidents with significant failure in safety provisions but with sufficient defence in depth remaining to cope with additional failures. • An event resulting in a dose to a worker exceeding a statutory annual dose limit and/or an event which leads to the presence of significant quantities of radioactivity in the installation in areas not expected by design and which require corrective action.	
1	ANOMALY	• Anomaly beyond the authorized operating regime. This may be due to equipment failure, human error or procedural inadequacies. (Such anomalies should be distinguished from situations where operational limits and conditions are not exceeded and which are properly managed in accordance with adequate procedures. These are typically "below scale".)	
BELOW SCALE/ ZERO	DEVIATION	No Safety Significance	

* *The doses are expressed in terms of effective dose equivalent (whole body dose). Those criteria where appropriate can also be expressed in terms of corresponding annual effluent discharge limits authorized by national authorities.*

The Convention on Nuclear Safety

Ed. Note: *The Convention on Nuclear Safety was opened for signature on September 20, 1994. As of April 1995, 56 countries had signed. It will come into force when 22 countries have ratified it (including 17 with at least one civilian nuclear plant).*

Within 30 months of coming into force the parties to the Convention must meet to review the status of safety of nuclear power plants in each country.

Canada has had a major role in the development of this Convention; Zig Domaratzki, Director General, Reactors, at the Atomic Energy Control Board, was chairman of the Group of experts that drafted the convention and Canada, through Dr. Agnes Bishop, president of the AECB, was the first country to sign the Convention last September.

Zig Domaratzki gave a talk to an over-flowing audience at a meeting of the CNS Sheridan Park branch, April 18. The following review of the steps leading up to the Convention and of its major points is taken from his notes.

Proposals for a convention on nuclear safety have been made for many years. In 1980, in the aftermath of the Three Mile Island accident, some saw the need for such an instrument. TMI had demonstrated that improvements should be made to the design and operation of what were until then thought to be very safe reactors. The objective would be to ensure that all countries applied the lessons learned from TMI and brought their safety practices up to an acceptable international standard. At that time, however, the proposal for a convention found little support.

In 1986, following the Chernobyl accident, two conventions were prepared, signed and promptly ratified. These were:

i) the Convention on Early Notification of a Nuclear Accident, and
ii) the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency

The objectives of these two Conventions are to ensure that in case of an accident measures will be taken to notify all States which might be affected, and to facilitate prompt assistance to countries that do not have the capability to take necessary counter-measures. Neither Convention addresses accident prevention.

The countries of western Europe were particularly concerned about the possibility of further accidents in eastern Europe. They saw a situation in neighbouring states where, in their opinion, reactor designs were inadequate to ensure safety, the regulatory framework was absent and there was an absence of a sound safety culture in the operation of nuclear power plants. A mechanism was necessary to ensure that a high level of nuclear safety was achieved and maintained worldwide. An accident in one country was clearly seen as an accident that affected the nuclear program in all countries. The incentive for a convention on nuclear safety was evident and many countries began to promote the idea.

The year 1991 was a milestone year. An IAEA Conference on the Safety of Nuclear Power: Strategy for the Future was organized in Vienna in September of that year to examine actions which should be taken to ensure that nuclear power would continue to be a viable option for the future. During the discussion several countries, with Germany being the strongest voice, promoted the idea of a convention on nuclear safety.

At the IAEA General Conference later that month a resolution was adopted inviting the Director General to prepare an outline of a possible nuclear safety convention.

First Steps: December 1991

The Director General of the IAEA, Dr. Hans Blix, moved quickly to respond to the resolution. In December 1991 he convened a meeting of legal and technical experts to advise on the possible elements of a convention. Thirteen countries and three international organizations were represented by 36 experts. The meeting addressed the possible form and structure of a convention, the scope, the specific elements to be included and the mechanism for ensuring compliance with the convention.

The experts agreed that there was a need for a convention on nuclear safety and urged that preparatory work should begin as soon as possible, although there was no agreement on the form of such a convention nor on its scope.

There was general agreement that the convention should embody the general safety principles found in two draft documents:

"Safety Fundamentals – The Safety of Nuclear Installations" being prepared by the NUSS Advisory Group. An advanced draft was available and has since been published by the IAEA.

"Draft Safety Fundamentals – The Principles of Radioactive Waste Management" being prepared within the RADWASS program. An early draft was available. An advanced version was tabled for consideration of the IAEA Board of Governors at its September 1994 meeting.

All the countries present at this first meeting shared the view that no supranational regulatory body should be created. There was agreement that neither the IAEA nor

any other international organization should be assigned any role that would require it to verify compliance with a convention.

The report of the December 1991 meeting was transmitted to Dr. Blix by the Board of Governors at its February 1992 session, which authorized him to set up an open-ended working group to prepare a nuclear safety convention.

Identification and Elimination of Obstacles

Preparatory work for the Convention began in May, 1992, when an open-ended group of experts met in Vienna. 100 experts from 45 countries, the CEC, NEA/OECD, and ILO began the deliberations which were to require six further meetings over a period of two years. (Domaratzki was elected chairman of that group of experts).

Two issues, in particular, divided the experts: the scope of the convention and the need for technical safety. At the outset a majority argued for a convention which would address the entire fuel cycle plus research reactors, transportation and the use of radioisotopes. A minority but nevertheless a significant number of countries argued for a narrow scope limited to the activity of greatest international concern, i.e. nuclear power plants.

It was not until the fourth meeting of the Group of Experts that deliberations had proceeded to the point that compromises were made by all participants. These compromises led to the position reflected in the Convention; basically it would be limited to land-based civil nuclear power plants. Waste management would not be included because there were no internationally agreed safety principles which could be applied to waste management. The convention would, however, include in the preamble a commitment to begin work on a convention on waste management as soon as there was broad international agreement on the safety fundamentals for waste management.

A second reference in the preamble was necessary to obtain the agreement of countries who preferred a very broad scope. The preamble therefore also recognizes that developments in the future may facilitate consideration of international instruments for other parts of the nuclear fuel cycle. Research reactors, the use of radioisotopes and transport of radioactive materials were understood to be covered by this reference.

The first meeting in 1992 also brought to the surface disagreements on the technical specificity required in the convention. Many were adamant that the convention should be modelled on the NUSSAG Safety fundamentals and should be limited to the statements of principles found in that document. Others considered that the obligations of contracting parties could only be clear if the convention was made more specific. Consensus on the need for technical details could not be achieved and at its fourth meeting there was agreement to proceed with fundamental principles only. All experts recognized that the NUSS documents could and would be used as valuable input when Contracting Parties met to review national compliance with the convention.

The details on the need to include technical criteria also highlighted disagreements on the role which the IAEA should play in the implementation of the convention. All parties agreed from the outset that the IAEA should *not* serve as a supranational regulatory body. In the Convention, as adopted, the role of the IAEA is limited to that of a secretariat albeit with some possibility of other functions added.

After four meetings, the fundamental disagreements had been resolved. The need for compromise was accepted by all in order to achieve the primary goal, a convention on the safety of nuclear power plants.

With this preparatory work completed, the Chairman of the Expert Group was asked to consolidate the work of the Group into a reference text which would be used for subsequent negotiations.

Finished Product

The chairman prepared a single reference text during the summer of 1993. This text was then reviewed in consultation with a number of countries. This consultative process involved not only countries from all regions of the world but also countries with widely disparate views and interests. The result was the first draft of a convention which found wide general acceptance, but three more meetings of the Group of Experts were required to improve it, refine it and agree on individual articles. In February 1994 the Expert Group (at its seventh and last meeting) considered that it had substantially completed its task and recommended that a Diplomatic Conference be convened to adopt the convention. The IAEA Board of Governors approved this course and a Diplomatic Conference was held from June 14 to 17, 1994.

During the Diplomatic Conference a limited number of amendments were made to the draft text of the Convention. The most significant changes were:

(a) Explicit reference in the objectives of the Convention to international co-operation (Article 1).
(b) The addition of a sub-article to recognize that the Agency will translate national reports into the designated language of the meetings of Contracting Parties (Article 26.3) and
(c) The decision to attach to the Final Act – rather than to the Convention – a text on clarifications regarding the meeting of the Parties.

The Final Act of the Diplomatic Conference includes an Annex with clarification on procedural and financial arrangements, national reports and the conduct of review meetings.

The Convention confers a role on the IAEA as Secretariat and to its Director General as Depository.

The Convention was then opened on September 20 for signature in conjunction with the 38th regular session of the General Conference of the IAEA.

Substance of the Convention: Technical Articles

It is not the intention to elaborate here on each of the articles of the Convention. Rather, some of the key obligations will be highlighted.

Preamble

The Preamble begins by referring to the need for a con-

vention on nuclear safety, recognizing that safety is a national responsibility and pointing to the existence of other related conventions.

Paragraphs (ix) and (x) of the Preamble do not relate to the substance of this Convention, but they refer to future negotiations of other conventions. Some argued that these references should not appear in the Preamble. However, they were necessary elements to achieve a consensus limiting the scope of this Convention to civil land based nuclear power plants.

Objectives – Article 1

The objectives are spelled out clearly in the first article:
- to achieve a high level of safety worldwide
- to protect people and the environment
- to prevent and mitigate accidents

The first objective makes reference to international co-operation including, where appropriate, safety-related technical co-operation. The specific reference to technical co-operation was controversial. The compromise achieved was to refer to technical co-operation only in the Preamble and in the article on Objectives. There is no reference to technical co-operation in the articles which impose substantive obligations.

Article 3, Scope of Application

The Convention applies to "the safety of nuclear installations." "Nuclear installation" is defined in Article 2 to mean "for each Contracting Party any land-based civil nuclear power plant under its jurisdiction; " an addition is made as to waste, i.e. "storage, handling and treatment facilities for radioactive materials as are on the same site and are directly related to the operation of the nuclear power plant." The definition also clarifies that "a plant ceases to be a nuclear installation when all nuclear fuel elements have been removed permanently from the reactor core and have been stored safely in accordance with approved procedures and a decommissioning program has been agreed to by the regulatory body."

General Provisions – Articles 4, 5 and 6

Articles 4, 5 and 6 can be considered as embodying the basic obligations of the Convention with the remaining articles being an elaboration of these three. Article 4 requires that a Contracting Party has or puts in place the laws, organizations and measures necessary to maintain a high level of safety. Article 6 requires that each Contracting Party reviews the safety of existing nuclear power plants in its country and takes any necessary corrective action. Article 5 is an obligation to submit for review by other Contracting Parties, reports on the measures it has taken to comply with the obligations in the Convention. Expressed in another fashion these three articles require a State to have the capability to achieve a high level of safety, that it utilizes this capability and that it reports its results.

Article 6 recognizes that when a Party ratifies the Convention the installations in its territory may not be in compliance with the obligations. In such an undesirable situation the Party would be obliged to take corrective action up to and including the shut-down of a nuclear power plant.

The three fundamental obligations are followed by thirteen articles (Articles 7 to 19 inclusive) which are based on NUSSAG Safety Fundamentals, which is however only a guide; the Convention is a binding international treaty. The language of the "Safety Fundamentals" document had to be modified, therefore, to make it suitable for an international treaty.

Article 10 which deals with priority to safety is less clear than the NUSSAG principle from which it was derived. That principle required the establishment of policies that give safety measures *highest priority*. Article 10 requires instead that nuclear safety be given *due priority*.

Article 16 on emergency preparedness has two interesting features – Article 16.2 obliges a Contracting Party to provide its own people with information on emergency planning and response. It also goes further and requires a Contracting Party to make available to nearby countries information necessary for planning before an accident and for responding after an accident occurs.

Article 16.3 requires a Contracting Party to prepare and test emergency plans even if it does not have a nuclear power plant in its country. A Contracting Party is obliged to have emergency plans to deal with possible accidents in neighbouring countries.

Article 17.4 on siting includes an obligation similar to Article 16.2. It requires a Contracting Party to consult with countries in the vicinity of a proposed installation. The obligatory consultation is limited, however, to countries that are Parties to this Convention. The purpose of the consultation is to enable the country in the vicinity to evaluate the likely impact on its territory. This obligation goes beyond making available the results of safety and environmental assessments. If requested, it entails an obligation to make available enough information to permit another Party to do its own independent assessment.

For countries which purchase rather than design and build their own nuclear power plants Article 19(v) could be problematic. This subarticle requires that "necessary engineering and technical support in all safety related fields is available throughout the lifetime of a nuclear installation." This suggests that purchasing countries will need to make arrangements with supplier countries for the lifetime of the installation. Alternately they would need to develop their own national capability.

Article 19(vii) formally recognizes the need to make internationally available important operating experience. The existing IAEA Incident Reporting System could be an appropriate mechanism for this international exchange. The filing of reports would, however, become a binding obligation rather than an informal commitment.

Meetings of the Contracting Parties

In general terms, the obligations to be undertaken by the Contracting Parties are of two different types: (i) *the first* is the requirement to take legislative, regulatory and administrative measures necessary to implement its obligations under the Convention. (ii) *The second* obligation is of a different nature. States undertake to

establish national reports on the measures taken "to implement each of the obligations of [this] Convention" *and* to submit such reports for "review" to meetings of the Contracting Parties.

These "review meetings" which are referred to by the negotiators as "peer review," analogous to the practice followed by nuclear regulators and other nuclear authorities and technical bodies in the context of the WANO (World Association of Nuclear Operators) and the IAEA, are the main innovative and dynamic element of the Convention.

The goal of the peer review process under this incentive Convention is not simply to determine whether the individual Parties have achieved the required level of safety. The peer review process should also be a candid discussion of problems encountered, solutions implemented and further actions required to achieve and maintain the required high level of safety. Where the necessary level of safety has not been achieved Parties would be expected to identify the actions and plans that they have instituted to correct any shortcomings. Thus the peer review process should not focus on specific deficiencies so much as on the direction and rate of improvement.

The need to further determine the modalities of the review process remained a major concern of the negotiators and led to the adoption of a document attached to the Final Act.

This document, which intentionally is attached to the Final Act of the Diplomatic Conference and not to the Convention itself, should provide some guidance on questions where the text of the Convention is silent or not sufficiently explicit. The usefulness of such a document was felt in the last round of negotiations and it became the common denominator for different concerns regarding the national reports, the conduct of review meetings and financial implications for the Contracting Parties and for the Secretariat in implementing the Convention. The main concepts expressed in the "clarification" are: added emphasis on the "national responsibility for nuclear safety;" the need for detailed and comprehensive reports to be submitted to and discussed by technical experts; consensus rule for all major decisions, and confidentiality. Furthermore, costs to Contracting Parties and to the Secretariat should be limited.

Guidelines for National Reports

The national reports are a crucial element to the success of this Convention. High quality reports will be necessary to permit a proper review by peers. The Convention states only that reports shall address implementation of each article.

The preparation of the National Report is solely a national responsibility. However, in preparing the reports, Parties can involve, to the degree and depth desired, outside organizations and experts, including requesting assistance from other countries or from the IAEA.

Process for Review of National Reports

There is unanimity on the importance of identifying an effective process for the peer review of national reports. There is, however, a wide divergence of views among countries as to how the process should be conducted. An Annex to the Final Act of the Convention identifies some of the principles which should apply. The Annex, which is not binding on the Contracting Parties, proposes some general principles; namely that the review process should:

- include in-depth study of all national reports, to be conducted by each Party before the meeting, as it deems appropriate;
- be carried out through discussion among experts at the meeting;
- take into consideration the technical characteristics of different types of nuclear installations and the likely radiological impact of potential accidents;
- identify problems, concerns, uncertainties, or omissions in national reports, focusing on the most significant problems or concerns in order to ensure efficient and fruitful debate at the meetings; and
- identify technical information and opportunities for technical cooperation in the interest of resolving safety problems identified.

Amendments

Changes to the Convention can only be made through a stringent formal amendment process laid out in Article 32; proposals for changes are to be considered either at regular review meetings, or at extraordinary meetings to be held if so agreed by a majority of the Contracting Parties, or, at the written request of one Party if such request is supported by a majority of the Contracting Parties.

Duration

The Convention is of unlimited duration. However, each Contracting Party has the right to withdraw from the Convention without providing reasons, by way of written notification to the Depository.

Conclusions

Entry into force of the Convention on Nuclear Safety is now within sight. This Convention is a unique opportunity to bring together all States that are building or operating nuclear power plants. Collectively we can achieve and maintain a high level of nuclear safety worldwide.

The risk perception gap†

BY EGON FRECH‡

Different Ways of Assessing Risk

Risk is usually defined by the technical community as a function of the probability of occurrence of an event and the severity of the harm or potential consequences of a single event, or[1]

$$R = P \times C$$

Most members of the public, however, view the risks of nuclear power as uniquely hazardous. In the case of nuclear waste, many see the risk as absolute rather than relative, and feel that unknown catastrophic events are somehow inevitable.[2] Researchers who conducted a word association test in Nevada in 1991 on the words "nuclear waste repository" found that the most frequent single associations were dangerous, danger, death and pollution.[3] They concluded that the responses revealed pervasive dread, revulsion and anger.

A survey conducted for Health and Welfare Canada in 1993[4] found that Canadians rank nuclear waste as the eleventh highest risk to their health, almost equal to their perceptions of risks from motor vehicle accidents, which kill about 4,500 Canadians a year, even though nuclear fuel waste is well managed and there is no public suggestion in Canada that there have been any specific victims of nuclear waste. The same study showed that Canadians have a special aversion to carcinogenic agents of any kind in their drinking water. Seventy-four per cent agreed (46% strongly) with the statement, "If even a tiny amount of a substance that can cause cancer were found in my tap water, I wouldn't drink it." When asked for their response to the statement, "No matter how low the level of exposure to radiation, it can still cause cancer," 62% agreed, 21% strongly.

Understanding the Gap

This difference between the general public view and that of experts on risk has been of some interest to social scientists, and the overall conclusion of the literature on the subject is that risk is not an objective phenomenon perceived in the same way by all parties. Instead, it is a psychological and social construct, its roots deeply embedded in the workings of the human mind and in a specific social context. Each individual and group assigns a different meaning to risk information. Each interested party – including those who generate the risk, those who attempt to manage it and those who experience it – sees it in different ways.[5]

Among the 30-40 factors that influence the perception of risk, the following appear to be most important in relation to radiological risks:

a) Voluntariness
b) Personal Controllability
c) Catastrophic Potential
d) Familiarity
e) Scientific Uncertainty
f) Effects on Future Generations
g) Trust in Governments and Institutions
h) Equity, Fairness and Benefits
i) Personal Stake
j) Reversibility
k) Origin (man-made vs natural)
l) Personal Values
m) Accident History
n) Effects on Children

How can society be best served in this situation? Many risk experts suggest that the public's "misperceptions" should be "corrected" through education programs so that society can apply the finite resources at its disposal to risk reduction in areas where the greatest good can be obtained. The common argument is that the concern should be about real lives, not perceived ones.[6]

The analysis is that the nuclear industry shares common values with the public in striving toward health and low risk, but that the public does not understand or appreciate this fact, and therefore a communications gap exists which must be overcome by education and public information programs. The expectation is that when the public has the same information as the technical experts, it will come to the same conclusions.

Despite the expenditure of millions of dollars on such information and education programs, however, the problem remains. Through the political process, the public often insists on expending vast sums on the further reduction of risks that are already very small, while virtually ignoring risks that kill thousands of people each year.

An alternative analysis of the problem, looking at the situation from the public's perspective, reveals that

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† This paper was presented to a special session at the ANS Winter Meeting, Washington, DC, Nov. 1994

‡ Now with R & R Enterprises Inc., Washington DC; formerly with AECL Research.

the nuclear industry in most cases is not providing what the public really wants. When the public says it wants low risk, it does not mean that it wants a low Probability times Consequence number, but rather that it wants voluntariness, controllability, etc. Therefore, the problem in fact is a *performance gap*, not a communications gap. In such circumstances, communicating what from the public's perspective amounts to irrelevant information can not be expected to have much amelioration effect.

Bridging the Gap

An examination of the factors influencing the public's perception of radiological risks reveals that many can in fact be accommodated in the design, development and public presentation of nuclear technology projects. Such an accommodation of the public's views would involve dealing with factors like voluntariness, controllability, reversibility, equity and fairness, benefits, and trust in institutions.

Increased voluntariness can be achieved by adopting approaches that allow considerable public involvement in decision making, such as voluntary approaches to site selection, and using agreement-building techniques for decision making and problem solving. In Canada, AECL is recommending a site selection process for a future nuclear fuel waste disposal vault in which the proponent would share decision-making power with potential host communities. Such a process would essentially provide for a host community veto on siting decisions. In the U.S., a similar course of action was followed by the Nuclear Waste Negotiator, leading to the potential for an MRS site to be hosted by the Mescalero Apache Nation.

Increased individual control can be accomplished by providing for community participation in monitoring, by establishing community advisory committees with authority to shut down non-conforming facilities,[7] equipping the public with the means to detect radiation (Geiger counters) and protect itself from some of its effects (iodine tablets), or other similar means.

A common argument is that when projects and proposals involve making irreversible decisions with irrevocable consequences, it is better to delay the action that might have such consequences "until we know more," even in the face of strong arguments that the status quo is undesirable. In response to this concern, both the Canadian and Swedish nuclear fuel waste management programs have proposed a long-range step-wise implementation plan with multiple decision points and monitoring phases. There is a recognition that we cannot in any case prevent future generations from exercising control over what they inherit, nor control whether they modify or even reverse today's decisions if that is what they deem the right thing to do.

Addressing equity requires processes to deal with impacts and their distribution relative to the distribution of benefits. Impact management programs that involve the coordinated application of mitigation, enhancement, compensation, monitoring and contingency measures can contribute to the acceptance of locally unwanted facilities. Guaranteeing local property values is one such mitigation technique.

Recent research shows that when most members of the public evaluate a risk, what they perceive may be a net value (the difference between risks and benefits) rather than a gross indicator of potential harm.[8] Governments and other proponents can enhance benefits by recognizing that there is a value to society generally from having a place to put generating stations, waste disposal facilities, etc., and sharing some of this value with the communities that host them.

One of the key factors in the perception of risk is the public's trust in the institutions that will be managing the risk. In the Canadian nuclear fuel waste disposal concept, it has been proposed that a site selection process based on safety and environmental protection, fairness, openness, voluntarism and shared decision making should enhance the likelihood of achieving mutual respect and trust.[9] Such a process would seek a site where technical suitability and public acceptance coincide, rather than applying a set of predetermined technical criteria to find the "best" technical site and then attempting to impose a facility on a potentially unwilling population in the name of the public interest.

Conclusion

How a technology is to be implemented is not strictly a technological determination, and decisions about what ought to be done involve much more than confidence in scientific and technological ability. Important factors are the need to respect different viewpoints and perspectives, and to consult the affected public and involve it in the decision-making process. The public acceptance of projects and proposals involving nuclear technology and radioactive materials is dominated by questions of values, fairness, rights and responsibilities.

Using radioactive material will always involve some degree of uncertainty, which the public may view in a way that ascribes an inflated value to the risks involved. Experience seems to suggest that attempts to bring the public's perception of risks more in line with scientifically-calculated values by providing information (education) have little positive effect. It may be more productive to recognize that the public will invariably incorporate non-scientific values in its decision-making processes about technology. Under such circumstances, projects and proposals dealing with nuclear technology and radioactive materials could be made more publicly acceptable by ensuring that their characteristics reflect the values used by most members of the public when making risk assessments.

References follow on page 20

References

1. Campbell, C.T., "Chemical Carcinogens and Human Risk Assessment," Special articles in Federation Proceedings (1980).
2. Foster, D., Nuclear Fuel Waste Management: A Preliminary Evaluation of the Social Issues, AECL Technical Record TR-332 (1985).
3. Slovic, P., Layman, P. and Flynn, J., Perceived Risk, Trust and the Politics of Nuclear Waste, *Science*, Vol. 254 (1991) 1603-1607.
4. Slovic, P., Flynn, J., Mertz, C.K. and Mullican, L., Health Risk Perception in Canada: A Research Report to the Department of National Health and Welfare, Government of Canada 693-EHD-170 (1993).
5. Covello, V.T., The Perception of Technological Risk: A Literature Review, in *Technological Forecasting and Social Change*, Vol. 23, No. 2 (1983) 285-297.
6. Lind, N.C., Health and Safety Policies: Guiding Principles for Risk Management, Report JCHS 93-1, Joint Committee on Health and Safety, Royal Society of Canada and the Canadian Academy of Engineering (1993).
7. Slovic, P., Perceived Risk, Trust and Democracy, *Risk Analysis*, Vol. 13, No. 6, Plenum Press, New York (1993) 675-682.
8. Gregory, R., and Mendelsohn, R., Perceived Risk, Dread and Benefits, *Risk Analysis*, Vol. 13, No. 3 (1993).
9. Greber, M.A., Frech, E.R. and Hillier, J.A., The Disposal of Canada's Nuclear Fuel Waste: Public Involvement and Social Aspects, AECL-1702, COG-93-2 (1994).

Real-time neutron radiography at McMaster

BY G.D. HARVEL and J.S. CHANG[1]

Neutron radiography is a process used world-wide predominantly for non-destructive testing of materials such as engine components and turbine blades. This type of technique is based on neutron attenuation in matter. Each isotope interacts with neutrons differently, hence, this allows for two different isotopes in a material to be identified, for example, a fuel leak in a metallic engine casing.

The McMaster Neutron Radiography Facility (MNRF) is fortunate to own the only Real-Time Neutron Radiography (RTNR) system in Canada. The RTNR system which has been developed here has tremendous advantages over conventional film-based neutron radiography in that real-time motion detection is now possible. The current state of the art for RTNR systems allows for the resolution of objects or defects on the order of 1.0 mm in a 32.0 ms period. Both the spatial and temporal resolution can be easily improved. Unlike film radiography, we can obtain real-time images in the form of video tape as well as hard copies of digitized images.

Current research at the MNRF involves the visualization of gas-liquid and gas-solid two-phase flow in complex flow channels such as nuclear fuel channels using light water, heavy water, freon-134A, slurries, and other fluids. A typical example is shown in Figure 1 where a gas bubble is seen in a stainless steel natural circulation loop. The RTNR image has been enhanced using image processing techniques for improved clarity. Two vertical lines are added to show the location of the stainless steel tube walls. Information regarding void fraction, void fraction distribution, bubble velocity, interfacial area, and bubble diameter has been determined using this technique.

Other research at the MNRF has examined single-phase flow, material purity, film deposition, turbine blades, and visual inspection of automotive parts. Other world research facilities performing RTNR have also studied automotive and aircraft components, fire extinguisher inspection, critical heat flux experiments, two-phase flow between plates, and mixing phenomena in large vessels.

The current commercial applications of RTNR systems has been limited to non-destructive examination of rotor blades for helicopters as most facilities in the world are still limited to conventional neutron radiography equipment.

The future of RTNR is quite significant both in terms of research and commercial applications. From the research point of view, several fundamental experiments remain in two-phase flow. Interfacial heat and mass transfer, boiling and condensation phenomena, flow induced vibration, and pressure drop phenomena can be extensively studied for many geometries found in industry today. Also, the RTNR system is ideal for process monitoring of hydrogenous materials.

From a commercial point of view, RTNR has two basic applications. The first application is for scanning a large object for large defect visualization such as rotor blades, automotive engines, and assembly line inspection of components such as turbine blades and capacitors. The second application is as a useful tool for optimizing the orientation of an object with respect to the radiation beam before conventional high resolution film radiography is performed. This application reduces lost time and film costs due to poor alignment of the object to be studied.

In summary, the Real-Time Neutron Radiography system at the MNRF will play a major role in future research and development of commercial applications.

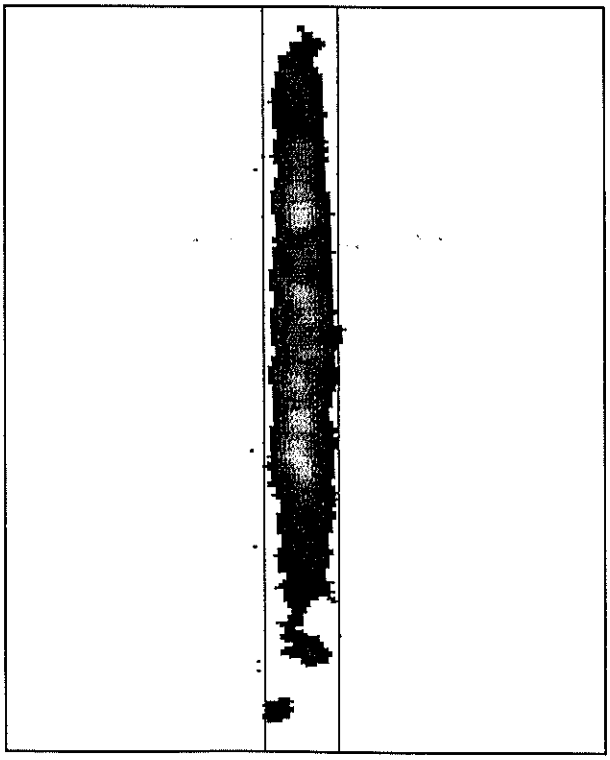


Figure 1: Real-Time Neutron Radiography Enhanced Image of a Gas Bubble in a Natural Circulation Flow Loop

[1] Department of Engineering Physics, McMaster University

Korean research reactor inaugurated

Senior officials from Canada and the International Atomic Energy Agency and Canada joined in the official inauguration of **HANARO** the Korea Multi-purpose Research Reactor, April 7, at the Korea Atomic Energy research Institute, Daeduk, Korea.

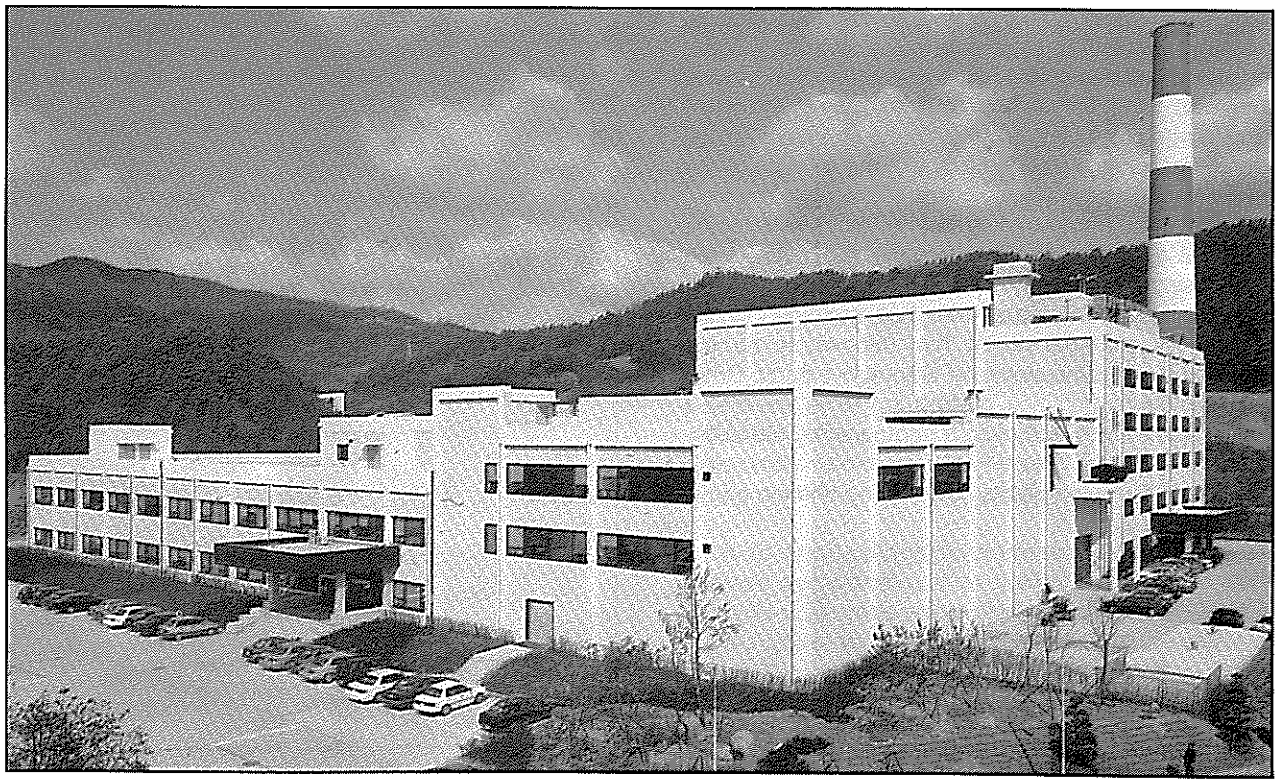
HANARO, previously designated as KMRR, is a 30 MW(th) pool reactor based on the MAPLE reactor concept developed by Atomic Energy of Canada Limited. The new name was chosen last year. Associated with the reactor is a full irradiation laboratory, with hot cells for fuel and materials testing, and radioisotope production.

A maximum thermal neutron flux of 5 x 10^{14} n/cm^2.sec. puts HANARO among the highest flux reactors in the world. Following the MAPLE concept the HANARO reactor has several inherent safety characteristics including the large heat sink of the surrounding pool, a negative reactivity coefficient, and ability for natural convection cooling. Reflecting Canadian power reactor safety philosophy, HANARO has an independent shutdown system. The reactor first achieved criticality on February 8.

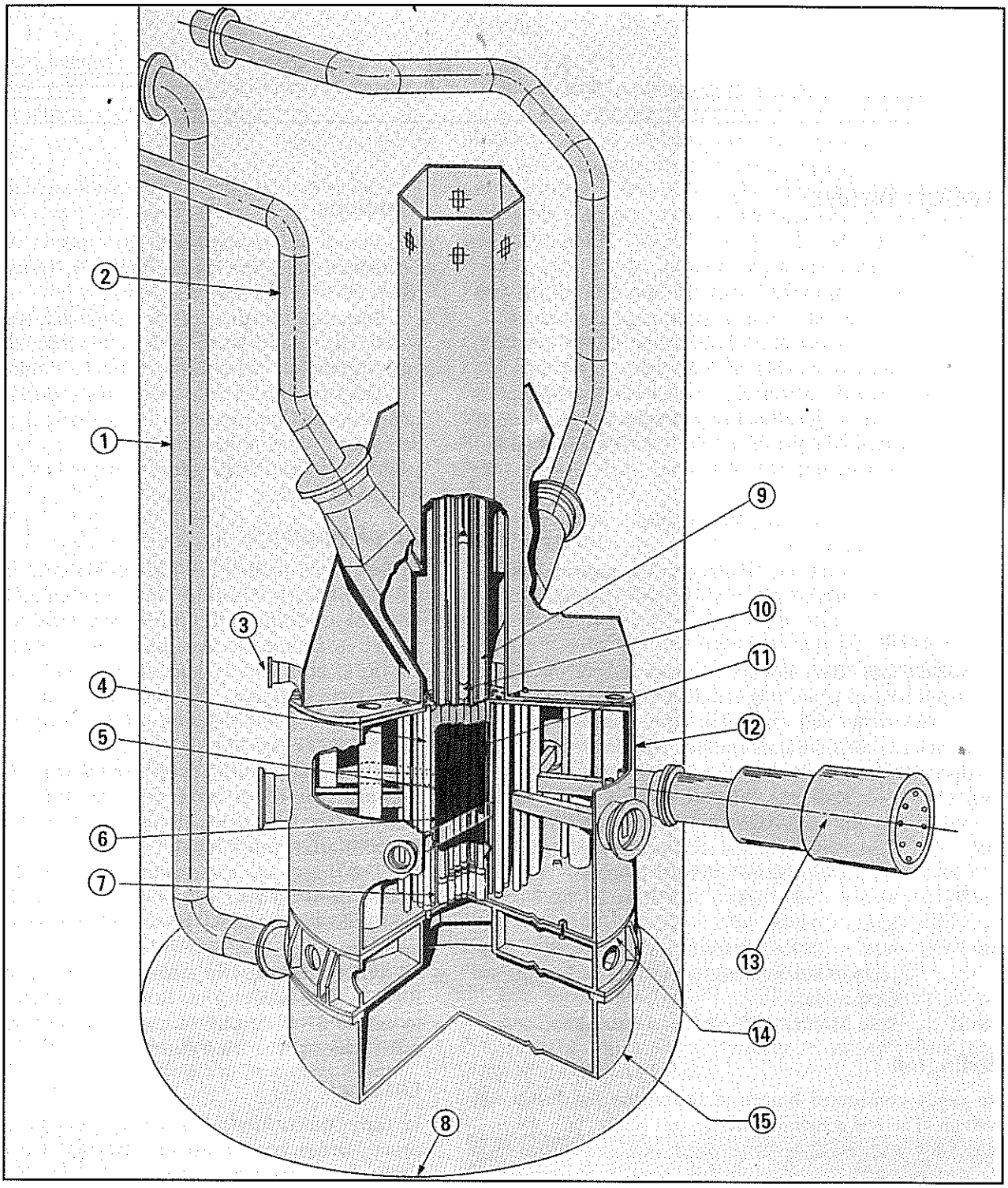
Prior to the HANARO ceremony, the Canadian Nuclear Association and the Korea Atomic Industrial Forum held a one-day seminar in Seoul focusing on advanced CANDUs, power reactor operation and international cooperation. AECL chief engineer, Dan Meneley, and CNS president, Ed Price, co-chaired, with Korean counterparts, the morning and afternoon sessions.

The week following the inauguration the IAEA held its first regional meeting on "Operational and Safety Issues in Nuclear Power Plants" in Pusan, Korea, near the site of the KORI station and about 75 km south of the Wolsong plant.

In his address at the inauguration IAEA Director General Hans Blix noted that Korea had evolved from being a technical assistance "user" country to a "supplier" one. He also made particular reference to the use of nuclear energy for the desalination of water, a technology which has received renewed interest over the past few years.



View of HANARO facility



Cutaway drawing of HANARO reactor structure

1. Primary Coolant Inlet Pipe
2. Primary Coolant Outlet Pipe
3. Heavy Water Outlet
4. Outer Fuel Site
5. Fuel Bundle
6. Flow Tube
7. Fuel Receptacle
8. Pool Liner
9. Shroud Tube
10. Shut-off Rod
11. Control Absorber Rod
12. Reflector Tank
13. Beam Tube
14. Grid Plate
15. Inlet Plenum

Branch News

Bruce

Eric Williams, of Bruce 'A' NGS, the new chair of the CNS Bruce Branch has led a re-organization of the branch. A program of talks at the BNPD Information Centre has been developed. The talk on March 7 by John Luxat and Ron Oberth on "Bruce's Potential role in Nuclear Weapons Disposition" drew a good audience despite bad weather, as did Juris Grava's talk, April 4, on "ITER Fusion Project." Scheduled meetings are:

May 2 Sam McGregor on "The Sustainable solution for the 21st Century"
June 6 Murray Elston on "Partnering the nuclear industry with agriculture"

Chalk River

The active Chalk River Branch continues to hold many talks and is involved in organizing the 50th Anniversary of ZEEP celebrations to be held at Chalk river, August 4-6. The annual Science for Educators seminar will be held April 27-29. Upcoming talks are:

April 27 Bob Rutledge, "Biotechnology in Forestry" (jointly with Algonquin College, Pembroke),
May 1 Don Anderson, GM of Ontario Hydro Nuclear on Ontario Hydro's nuclear program,
May 9 Morris Rosen, IAEA, "The International Nuclear Safety Convention"
May 24 AGM with Ken Petrunik, Vice-president, projects, AECL CANDU, providing an update on Cernavoda,
June 20 Reid Morden, President and CEO, AECL.

Darlington

The newly constituted branch at Darlington has had a full program. The one remaining talk in this season is:

April 26 Bruce Lang, "Disposal of nuclear waste"

A General Meeting will be held June 21 to review this first year and outline plans for the 1995-96 season, including a tour of Ontario Hydro's Clarkson Energy Control Centre in September.

Golden Horseshoe

With two talks in March, on "Nonlinear transition in two-phase flow" and "Radiation, what defines the risk?" and one in early April on the "Pickering U2 incident" the branch has completed its scheduled lecture meetings. The popular Career Night is being planned for August.

Manitoba

The Branch was involved with the CNS/CNA Annual Student Conference which was held in Winnipeg, March 9 to 11. (See report elsewhere in this issue.)

Remaining meetings in this season are: April 24, Robert Nixon, chairman of AECL, and, to be scheduled, Jan Cramer on "Nuclear fuel waste management and natural analogues".

The Branch will be assisting in the organization for the International Conference on Deep Geological Disposal of Radioactive Waste to be held in Winnipeg, September 16 to 19, 1996. Chuck Vandergraaf, past president of the Branch, is on the organizing committee.

New Brunswick

At the branch meeting in January, Malcolm Callister spoke on "The Current Status of the Environmental Qualification Program at PLGS". In February there were two talks: Brent Daniel, Maritime Nuclear, on "Development of Advanced CANDU Control and Monitoring Systems"; and Jatin Nathwani, Ontario Hydro, on "Narora (India) Station Blackout Due to Turbine Fire". March saw Jim Brogan describing the "1995 PLGS Outage".

The annual Branch dinner meeting will be held May 2 at the Saint John Hilton hotel, with two speakers; Rick Wardman on "Cernovoda experience" and Stu Groom on "NB Power, Marketing in China".

The Branch has contributed $300 to the Malcolm Lightfoot memorial scholarship which was created at Saint John high school in memory of the son of one of the branch members.

After assisting two students to attend the 1994 Deep River Science Academy the Branch has decided that this year to donate $700 directly to the Academy's bursary fund to assist students from New Brunswick.

Ottawa

In early March Merle Griebenow, from Idaho Falls, spoke about "Boron neutron capture therapy." On April 6, Jerry Cuttler described the December 10, 1994, Pickering unit 2 incident.

The annual banquet will be held April 26 with Dr. Agnes Bishop, president of the AECB, as the guest speaker.

The Branch is assisting with the Ottawa Regional Science Fair and is organizing a trip for high school students to Theratronics in June.

Pickering

The next talk (with the date still to be finalized) will be by Don Dautovich of CFFTP, on "The next step to international fusion energy development."

Quebec

A visit to the IREQ tokamak facility at Varennes was held in early February and another tour, to GEC Alsthom (builders of the Wolsong calandrias), is planned for May.

Saskatchewan

Members of the Branch are very involved with planning for the Annual CNA/CNS Conference which will be held in Saskatoon, June 4 to 7.

Branch members are working on submissions for the environmental review of Cigar Lake and the nuclear fuel waste disposal concept.

Talks are planned by Nobel Laureate, Dr. Bertram Brockhouse, Eric Malling, from The W5 television program, and Donald Johnston on the OECD.

Sheridan Park

Zig Domaratzki, of the AECB, gave a talk, April 18, on the new Nuclear Safety Convention. He was the chairman of the group that drafted the convention.

On May 23, C. Crawford will describe "Decommissioning a nuclear plant in Colorado."

In January the Branch arranged a tour of Darlington NGS for 80 grade 12 students. A prize is being given at the Peel Regional Science Fair.

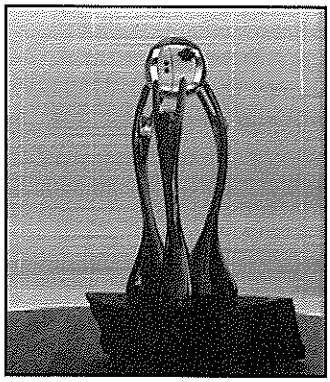
Toronto

Two talks were held in March. Merle Griebenow spoke on "Born neutron capture therapy for treatment of cancer," and Ron Mitchell on "Radiation, what determines the risk?". In April Peter Boczar spoke on "CANDU advanced fuel cycles – from garbage burning to global disarmament."

Hilary Freitas, a graduate student at the U of T received the 1995 R.E. Jervis Award.

In March U of T students participated in the CNA/CNS Student Conference in Winnipeg and the ANS Student Conference in Atlanta. (See separate articles.)

As nominated by guest speakers, $100 was given to each of the following schools for a scientific excellence award: Branksome Hall Girls School, Toronto; Pinawa Secondary School, Pinawa; Central Technical School, Toronto; Mackenzie High School, Deep River; Montcalm Secondary School, London.



The Innovative Achievement Award

News of Members

Dr. Adi Dastur, recently retired from AECL CANDU has been appointed **Engineer Emeritus** by Chief Engineer Dan Meneley. This is an honourary new position designed to allow Adi to continue his pioneering work into the physics of advanced CANDU fuel cycles. The focus of his work will be on burning actinides in CANDU reactors. (See a paper on this subject by Adi in *CNS Bulletin*, Vol. 15, No. 3, Fall 1994.) Adi was presented an Outstanding Achievement Award by the Canadian Nuclear Association in 1994.

Philip McKenzie, a graduate student at the University of New Brunswick won the CNA Youth Energy Symposium essay contest for his paper, *"Nuclear Power: A 'Green' Option"*. His prize is a trip to the World Energy Conference to be held in Tokyo, Japan, next October. Philip is the son of Roger McKenzie, formerly of NB Power.

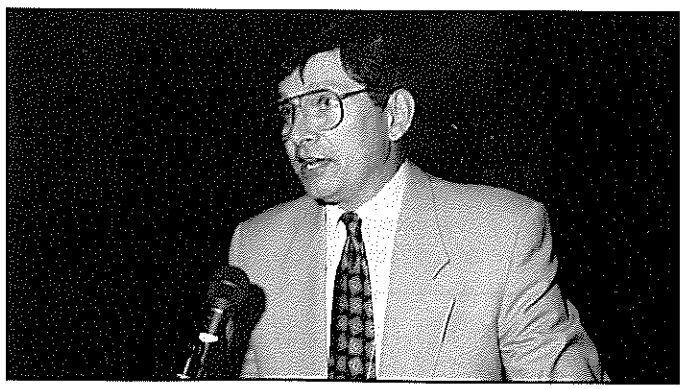
In Memoriam

It is with great sadness that we report the sudden death of **John Hewitt** on April 27 at the age of 56. He suffered a severe heart attack the day before and did not recover.

One of the organizers of the Canadian Nuclear Society, John was the third president, in 1983-84, and was instrumental in beginning the *CNS Bulletin*. He remained active in the Society and was, among other roles, chairman of the Honours and Awards Committee for a number of years. More recently he took on the chair of the Past Presidents Committee. In 1992 he was one of the first persons named as a Fellow of the CNS.

Many will remember John as a professor of nuclear energy at the University of Toronto in the 1970s and 1980s. Two years ago he joined the Nuclear Energy office of Natural Resources Canada. In between he worked for consulting firms and the Canadian Space Agency.

John exemplified the best qualities of a professional; he was intelligent, knowledgable, objective and thorough. More than that, he was a warm, considerate, helpful friend that many of us will miss greatly.



John Hewitt on the occasion of becoming a Fellow of the CNS

Toronto once again triumphs in Atlanta

by Edward Panyan*

The American Nuclear Society's 20th Annual Student Paper Conference for the Eastern Region was held in Atlanta, Georgia. The 30 degree plus weather (that's Celsius not Fahrenheit – and it was only March!) provided the perfect atmosphere for the two day conference. Six engineering students from the University of Toronto were invited to present papers on their current research at the Georgia Institute of Technology where this Canadian contingent was subsequently welcomed with impeccable Southern hospitality. The six were: Paul Bekeris, Ka Hing Lin, Antonio Criminisi, Edward Panyan, Rajesh Dhoum, and Shital Sethi.

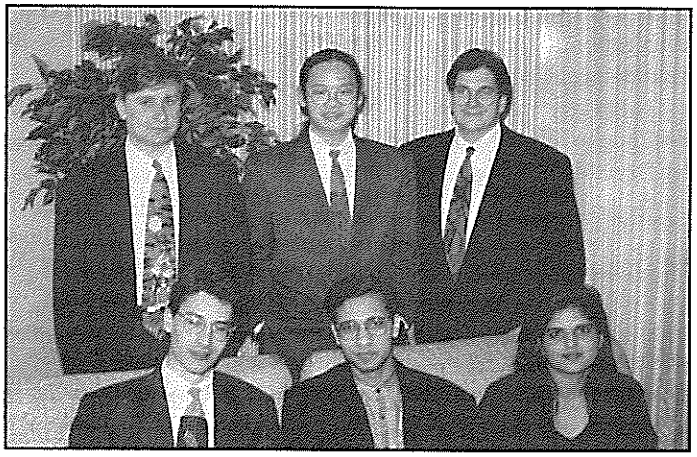
Students from Ohio State, Massachusetts Lowell, Florida, Maryland, Penn State, Tennessee – Knoxville, and even one from California (we figured he took a left turn on the wrong interstate) were in attendance. A total of 100 delegates, of which 52 were presenters, provided an interesting cross section, not to mention several interesting accents, for the conference.

The conference itself consisted of six sessions. These sessions included topics on Reactor Physics and Transport, Materials, Detection and Dosimetry, Computers and Electronics, Benchmarks, Nuclear Reactor Design, Biology, Health Physics and our favourite, Iodine Chemistry. Corresponding with the South's reputed easy-going style, the six sessions were held in the press boxes of Georgia Tech stadium, which offered a panoramic counterpoint to the information presented. The papers themselves were very informative and afforded us a great opportunity to discover what our American neighbours are focusing their current research efforts on.

Awards and invitations to the national ANS conference were given out to presenters who demonstrated both exceptional content and presentation skills. The University of Toronto was well represented in this regard having two winners for best papers in their sessions. The winning presentations were: for the graduate level, "A study of Partition Coefficients, Hydrolysis and Radiolysis Rates for Organic Iodides" by Ka Hing Lin, and, for the undergraduate level, "Radiolytic Iodate Formation in Aqueous Cesium Iodide Solution" by Tony Criminisi. It must be something in the Georgian air that induces Toronto representatives to excel regardless of whether it involves academic or sporting pursuits (yes, they're still bitter about the Blue Jays in '93).

The conference itself wasn't all work and no play. Our hosts offered generous hospitality including a tour of the campus' 5 MW research reactor and facilities which is currently focusing its research efforts in the construction of a brain cancer treatment facility.

Georgia Tech should be congratulated for their excellent efforts in hosting this conference. The students who participated would like to thank them for the invite and the various agencies who provided funding to make this trip possible.



U of T students at ANS Student Conference in Atlanta, March 1995; back row, l. to r. Paul Bekeris, Ka Hing Lin, Antonio Criminisi, front row, l. to r. Edward Panyan, Rajesh Dhoum, and Shital Sethi.

CNA/CNS Annual Conferences

This is the year to go west.

Once again the joint CNA/CNS Annual Conference will be held in Saskatoon, the capital of the Canadian uranium mining industry and the location of an AECL CANDU design team.

Those who attended the last conference held in Saskatoon will remember the excellent organization and warm hospitality (even the small protest group were reasonably pleasant).

This year's conference will be held in the Sheraton Cavalier Hotel from Sunday, June 4 to Wednesday, June 7.

There are actually two conferences running in conjunction with one another. This is the 35th (how time flies) annual conference for the Canadian Nuclear Association and the 16th for the Canadian Nuclear Society.

As usual the CNA Conference will focus on broader industry issues while the CNS one will be technically oriented. The CNA Conference will have a number of invited speakers presenting papers in several areas:

- Industry updates
- Non-proliferation issues
- Waste disposal
- Regulatory issues
- Trade
- Markets
- Economics
- Public acceptance

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* Edward Panyan is a graduate student in the Department of Chemical Engineering and Applied Chemistry at the University of Toronto working under the guidance of Prof. Greg Evans, who is chairman of the CNS Toronto Branch.

Some of the specific papers will address:
- The new AECL
- Plans for Ontario Hydro
- The Atomic Energy Control Act
- emerging markets

The concurrent CNS technical conference will have 16 sessions in which 87 papers will be presented in various aspects of:
- reactor physics containment
- safety and licensing
- control and instrumentation
- fuel and fuel channels
- engineering and maintenance
- new reactors and applications
- computers applications
- severe accidents.

Presentation of CNA and CNS awards will be made at the luncheons which are part of the program (and registration). As usual there will be a reception on the Sunday evening. The traditional banquet will be replaced by a "Wild West Night" at a local ranch.

An additional feature is optional tours to mines in northern Saskatchewan. For a nominal fee those involved will be flown to either Cluff Lake or Key Lake mines. From similar trips at the last conference in Saskatoon either of these tours offers a fascinating view of the north and a glimpse of large uranium mining complex.

For further information contact:
Michel Panchuk
Tel. 306-373-0697 FAX 306-955-8833
For conference registration contact:
Ed Hinz
Tel. 306-374-8242 FAX 306-374-0909

20th Annual CNA/CNS Student Conference

by Darryl Dormuth

This year, 38 students from Saskatchewan to Newfoundland to New York attended the 20th Annual CNS/CNA Student Conference held in Winnipeg on March 10 and 11, 1995, at the University of Manitoba. The three member committee worked hard to organize events for, and associated with, the conference. Feedback from attendants suggested that they did a good job.

Prior to the start of the conference, on March 9, about 20 delegates toured the Whiteshell Laboratories and the Underground Research Laboratory located 100 km northeast of Winnipeg at Pinawa. They viewed several experiments, at both sites, which provide important information to AECL's reactor safety and nuclear fuel waste management programs. All delegates agreed it was well worth the hour-and-a-half bus ride. Upon returning to Winnipeg, some students participated in an East-West pool tournament at a local bar. No one is sure who won.

The conference began Friday, March 10 at noon. For two days attendants heard high quality presentations from students at the Bachelor's, Master's, and Doctorate levels. The sessions included a variety of topics: Nuclear Chemistry, Thermalhydraulics, Radiation Applications, and Reactor Design and Safety. A four member panel of judges composed of Mr. Ed Price (President of the CNS), Dr. Jerry Cuttler (1st Vice-President of the CNS), Dr Doug Ruth (University of Manitoba) and Dr. Arthur Chow (University of Manitoba) reviewed all presentations. They had a difficult task and in the end the following students were awarded prizes:

Bachelor's Level

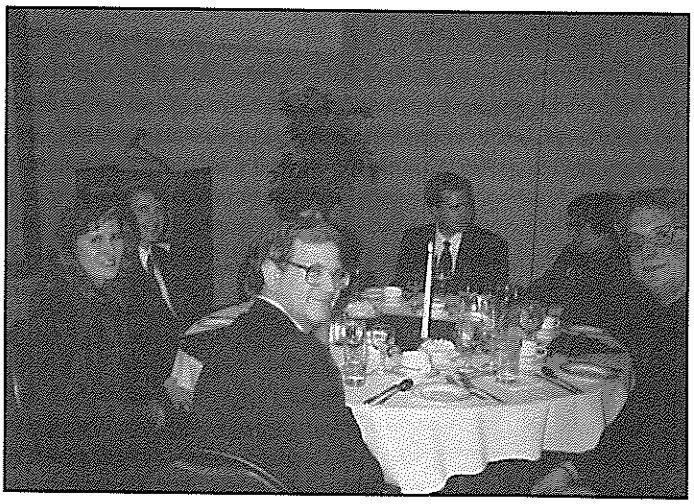
1st Place:	Teresa Tutt	Rensselaer Polytechnic Institute (New York)
2nd Place:	Layne Botterill, Paul Sauder and Cameron Stephenson	University of Saskatchewan

Master's Level

1st Place:	Lisa Lucht	University of Manitoba
2nd Place:	(tie) Matt Krause	University of Manitoba
	Johanna Johari	University of New Brunswick

Doctorate Level

1st Place:	James Noël	University of Manitoba



Enjoying the banquet at the CNA/CNS Student Conference in Winnipeg are: (clockwise from lower centre) Jerry Cuttler, CNS Vice-President, Kristen Torgeson, Glenn Gowa, Mami Dormuth, Darryl Dormuth, Dr. Agnes Bishop, president of the AECB, Paul Driver.

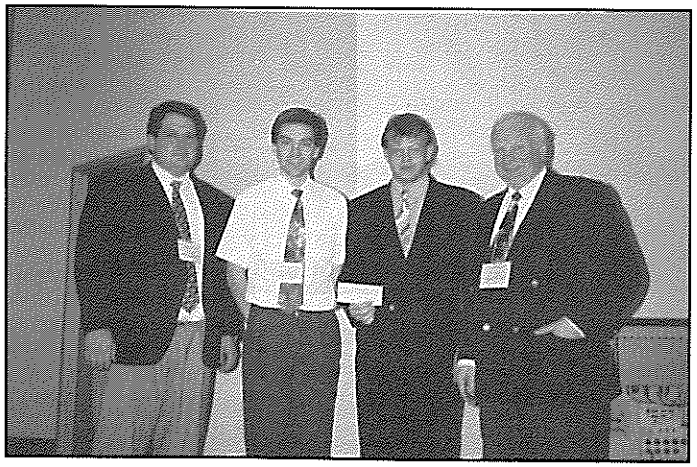
On Friday night delegates and industry guests attended a formal banquet at the Winnipeg Delta Hotel at which Dr. Agnes Bishop, President of the Atomic Energy Control Board, was the guest speaker. Her talk entitled "2001 – A Safety Odyssey" touched on

the many challenges which the AECB will face in the coming decades including the regulation of Canada's aging reactors and the disposal of nuclear fuel waste. She stressed the need for the AECB and the nuclear industry to be upfront with Canadians and cited the recent Pickering incident as an example of how both can work together to disseminate information to the public. She also discussed the importance of nuclear safety and regulation pertaining to university research reactors and how things may change if the Atomic Energy Control Act is revised to reflect today's nuclear industry. Dr. Bishop gave a very informed an captivating talk, despite having dental surgery two days before and a previous speaking engagement that day.

The conference resumed the next morning with a talk by Mr. Bob Lidstone (AECL) on the proposed new research reactor to replace NRU, the Irradiation Research Facility. Around 4 pm everything wrapped up with the awards presentation and closing remarks. Mr. Ed Price indicated that next year's conference will held in Ottawa.

During the conference "off-hours" delegates did a variety of things including shopping, pub hopping, relaxing by the hotel pool, and attending an NHL hockey game (Toronto students liked the ticket prices). There was also a resumption of the East-West pool tournament, but again, no one is sure who won.

The organizing committee, comprised of Darryl Dormuth, Paul Driver and Glenn Glowa, would like to thank all those people who helped make this conference a success: the judges, the session chairs, the Manitoba Branch of the CNS, and all other individuals who aided in the organization. We would also like to thank those sponsors who generously donated towards the conference: CNA, CNS, AECL, Ontario Hydro, Cameco, Babcock and Wilcox, SaskPower, Manitoba Hydro, Uranerz, Natural Resources Canada, Manitoba Ministry of Education, Manitoba Ministry of Energy and Mines, Manitoba Ministry of Industry and Trade, Industry Canada, Society of AECL Professional Employees, Wardrop Engineering, Economic Innovation Technology Council, Uranium Saskatchewan, Institute for Technological Development, and the Canadian Nuclear Workers Council. The committee enjoyed planning and running this event and we wish organizers of next year's conference all the best.



CNA president Ed Price poses with Paul Sauder, Cameron Stephenson, and Layne Botterill after presentations at the CNA/CNS Student Conference in Winnipeg in March, 1995.

Ed. Note:: To give readers an impression of the quality of the papers presented at the 20th CNA/CNS Student Conference abstracts of the winning papers are presented below.

Abstracts of Papers from CNA/CNS Student Conference

1st place Bachelor's level

X-Ray Spectroscopic Technique for Energetic Electron Transport Studies in Short-Pulse Laser/Plasma Interactions

T.E. Tutt, Rensselaer Polytechnic Institute

When a solid target is irradiated by a laser beam, the material is locally heated to a high temperature and a plasma forms. The interaction of the laser with plasma can produce energetic electrons. By observing the behaviour of these "hot" electrons, we hope to obtain a better understanding of Laser/Plasma Interactions. In this work we employ a layered-fluorescer technique to study the transport, and therefore the energetics, of the electrons. The plasma forms on a thin foil of metallic Pd which is bonded to thin layer of metallic Sn. Electrons formed from the plasma penetrate first the Pd and then the Sn. In both layers the energetic electrons promote inner (K) shell ionization of the metallic atoms which leads to the emission of characteristic K_α X-rays of the fluorescers. By recording the X-ray spectrum emitted by the two foils, we can estimate the energy-dependent range of the electrons and their numbers.

1st place Master's level

Recovery of Microorganisms from Potentially Lethal Radiation Damage

Lisa Lucht, Joseph Borsa and Greg Blank, University of Manitoba

Food processing treatments, such as irradiation with ionizing energy, which are designed to reduce microbial populations, can leave a substantial portion of the surviving population in a damaged but recoverable state. Recovery from potentially lethal damage could reduce the efficacy of the process and therefore requires consideration. This work examined the effect of dose and post-irradiation holding temperature on the recovery phenomenon. The kinetics of damage repair and fixation were examined. Radiation induced damage was compared to heat induced damage. The results indicate that for E. coli and S. typhimurium recovery can significantly lower the killing efficacy of irradiation. The magnitude of recovery is related to dose. Potentially lethal damage caused by irradiation differs from that caused by heating, suggesting different mechanisms of damage.

1st place Doctorate level

Electrochemical Noise Signals in Titanium Crevice Corrosion

James J. Noël and David W. Shoesmith, University of Manitoba and Whiteshell Laboratories

To develop a deterministic understanding of individual localized corrosion phenomena occuring during the crevice corrosion of titanium, a series of electrochemical measurements on artificially

creviced Grade-2 titanium has been initiated. The creviced specimens were electrically coupled to uncreviced electrodes of the same titanium alloy through a zero-resistance ammeter in order to separate the anodic and cathodic half-reactions in space and to permit simulataneous measurement of the corrosion potential and corrosion current. The observed signals suggest that the crevice corrosion process consists of a large, long-lasting (weeks or months in these experiments), "background" phenomenon, upon which are superimposed many short-lived (ranging from tens of seconds up to several hours) corrosion events. This talk will describe the analysis of these signals to quantify the "background" process and the shape, size, event frequency, and other properties of the short-lived events.

2nd place Master's level

Modelling of Flow-Assisted Corrosion in CANDU Outlet Feeders

J.M.C. Johari, N. Arbeau and D.H. Lister, University of New Brunswick

Semi-empirical models to predict carbon steel corrosion and hence magnetite growth in the primary side of CANDU reactors do not normally take into account high flowrates and iron under saturation in the outlet feeders. Such condition results in the formation of a single oxide layer rather than the double layer observed in the inlet feeders where the bulk coolant is saturated with dissolved iron. The idea developed in this paper accommodates the effect of high coolant velocity on the material corrosion by employing a term for oxide removal by physical forces. The results of the predictions of iron transport in the outlet feeders are compared with the steam generator deposits in operating CANDU reactors.

2nd place Master's level

Steam Condensation in the Presence of a Noncondensable Gas

Matt Krause

A previously developed model that uses a finite control volume method, applied to an adaptive, non-orthogonal grid, to solve the complete two-phase boundary-layer equations for laminar film condensation has been improved by coupling the equations of some of the solution variables. While in previous work the condensate thickness and the conservation equations for momentum, energy, mass and noncondensable mass in the vapour-gas layer are solved separately in an iterative procedure, the method described here couples the equations for the condensate thickness, mass and noncondensable mass conservation in the vapour-gas layer. The coupled equations are linearized and solved simultaneously using a penta-diagonal matrix algorithm. Nonlinearities arising from the coupling and the remaining non-coupled equations for energy and x-momentum still necessitate iteration, but a significant decrease in the number of iterations and computing time is anticipated.

This paper briefly outlines the computational model and the method of coupling the equations. Some preliminary results showing an improved computational efficiency are presented.

2nd place Bachelor's level

Retention Mechanism for Fuel Channel Inlet Shield Plug

Cameron Stephenson, Layne Botterill and Paul Sauder, University of Saskatchewan

The purpose of the design project proposed by Atomic Energy of Canada Limited was to design and produce drawings of a device to retain the inlet shield plugs in the fuel channels of the CANDU 3 nuclear reactor. The device was to have a long service life and allow the plugs to be removed by remote tooling.

After considering several preliminary concepts, a final design was selected. The final design involves separating the collar of the inlet shield plug into two sections which are threaded together. By threading together the two sections of the collar inside the fuel channel, a split ring is securely located within a groove in the channel wall. The interaction of the collar with the ring prevents the shield plug from moving.

A scale model was constructed to assess the feasibility of the design concept. The scale model verified the design concept and indicated areas to be considered in the stress analysis.

Both the cases of normal operation and channel failure were examined. The analysis considered the shear stress in the ring, the bearing strength of the grooves, the buckling strength of the collar and the bending stresses in the split ring when compressed. It was shown that the bending stresses in the ring were the greatest concern. However, according to the stress analysis, the final restraining device meets all of the design requirements.

If an inlet shield plug is removed, it is recommended that the ring be replaced since the initially high yield strength may be reduced from the material being exposed to high temperatures for several years. It is also recommended that experiments be conducted to determine the effects of corrosion, elevated temperature, and irradiation on the mechanism. Before implementing this design a finite element analysis should be conducted and a remote cooling device needs to be designed for insertion and removal of inlet shield plug.

Spaced Out

by Gerry Gaboury

On Wednesday February 8, Dr. Ken Kozier gave a presentation on space applications of nuclear power and propulsion to the Toronto Branch of the CNS at the University of Toronto. Dr. Kozier is a Senior Consulting Analyst in Reactor Physics at AECL Research (Whiteshell). He says he's been interested in this topic since 1978 when he had the opportunity to examine the wreckage of COSMOS-954 that came down in northern Canada. He got really interested in the technology when he became involved in a small reactor project that AECL had with the US DOE and Los Alamos National Labs (LANL) and had the chance to meet some of the people involved in the ROVER/NERVA work at LANL. He has done other work in the area but now keeps up with developments as a hobby.

I found this presentation particularly interesting as much of this information was new to me. Space travel is less than half century old and our propulsion technology is in its infancy. All modern propulsion systems of which I am aware, are chemically based and I had not heard of any serious effort toward other forms of propulsion. While chemical systems may be adequate (sometimes marginally) for interplanetary travel, these systems are obviously inadequate if we are to seriously consider interstellar travel. It would be nice if "warp" technology were just around the corner but I don't think that's the case.

The areas of application covered by Dr. Kozier were: electricity generation, process heat and propulsion. The application of nuclear power for electricity generation would be where photovoltaic solar panels wouldn't be adequate, such as deep space missions where solar radiation is of diminished intensity or where power demand is high and the required solar panels would be too large. The two basic types of nuclear-electrical sources are radioisotope and nuclear fission reactor. From the list of Space Nuclear Power Systems launched by the United States, the vast majority were radioisotope thermoelectric generators (RTG) but there was at least one example of a reactor. The Voyager probes, which have been the source of spectacular images, used RTGs. If a process heat source is required, this would likely be a byproduct from electrical generation or propulsion but could be a primary application itself.

The areas where reactors are preferable to radioisotopes as a power source were outlined, mainly high power demand applications. The basic design features of a space-based reactor such as fuel types, heat transport system, power conversion system, heat rejection system and shielding were covered. An interesting feature of these reactors is that they are fast reactors with possibly a liquid metal coolant. Because the waste heat will be radiated into space, it is desirable that the radiator be at as high a temperature as possible. Some diagrams for the General Electric SP-100 and the Russian TOPAZ-2 were shown.

Lastly, propulsion systems were discussed. The theoretical specific impulse for various power/propulsion systems, ranging from liquid fueled chemical rockets to matter annihilation, were given. Some examples of actual nuclear thermal rocket engines which have been built were shown. The best design of this type, which would heat H_2 by passing it through the reactor core, would be roughly twice as effective as the best chemical rocket. Unfortunately time permitted only a brief discussion of other forms of propulsion such as nuclear-electric or impulse drives.

I found Dr. Kozier's presentation a refreshing departure from the norm. I concur with his opinion that space nuclear power is either essential or inevitable and that a compelling mission is what is required for the development of the technology. He said that this is just a hobby of his. Good hobby!

Biography

Dr. Kozier has a B.Sc. (1972) and a Ph.D. (1977) both in Physics from the University of Manitoba. He has been with AECL for 17.5 years. Gerry Gaboury has a Ph.D. (1993) from McMaster University. He has worked in the area of reactor physics at Ontario Hydro for 4.5 years.

Further Reading (provided by Dr. Kozier)

1. *Proceedings of the Annual Symposium on Space Nuclear Power Systems*, University of New Mexico, Albuquerque, N.M., (starting in 1984).
2. *Proceedings of the Annual Intersociety Energy Conversion and Engineering Conference* (I.E.C.E.C.)
3. "Nuclear Power in Space," S. Aftergood et. al., *Scientific American*, 1991 June.
4. *Outlook on Space Reactors*, Special Report to: Nucleonics Week, 1992 Sept. 24, Nuclear Fuel, 1992 Sept. 28, Inside N.R.C., 1992 Oct. 25.
5. *Space Reactor Electric Systems: Subsystem Technology Assessment*, R.V. Anderson et. al., Rockwell International, ESG-DOE-13398, 1983 March 29.
6. *Space Nuclear Power*, J.A. Anderson & D. Buden, Orbit Book Company Inc., Malabar FL, 1985.

International Conference on Deep Geological Disposal

Program

The Canadian Nuclear Society will host an **International Conference on Deep Geological Disposal of Radioactive Waste** in Winnipeg, Manitoba on 1996 September 16-19.

Designed to bring together experts from many countries that have, or are developing, geological disposal technologies, the conference will provide a global focus on current research and implementation strategies. Presentations will address technical, social and economic aspects of deep disposal of low, intermediate and high-level radioactive waste.

Presentations will include developments in all subjects relating to deep geological disposal of radioactive wastes, including advances in the state-of-the-art technology and on potential future development. In particular the following topics will be emphasized:

- International Trends (Plenary)
- Status of Underground Laboratories and Disposal Facilities
- Siting and Site Characterization
- Disposal Facility Engineering
- Engineered Barriers
- Impact on the Biosphere
- Social Issues and Public Consultation
- Regulatory Issues
- Environmental and Safety Assessment

Technical Tours

In addition to the conference program, a full-day technical tour will be offered of AECL's Underground Research Laboratory (URL) and the Whiteshell Laboratories, which are located about a two-hour drive east of Winnipeg.

The URL, completed in 1990, was constructed as part of the Canadian Nuclear Fuel Waste Management Program to perform large-scale, in situ experiments in plutonic rock of the type expected to be suitable for deep geological disposal of nuclear fuel waste in Canada. It was the first such test facility in the world to be built below the water table in previously undisturbed granitic rock. Nine major experiments are presently underway at depths of up to 420 m to examine aspects of deep geological disposal. The experiments include the development and demonstration of site characterization methods, solute transport studies, excavation response studies, vault sealing studies, and disposal vault room simulations.

AECL's Whiteshell Laboratories is one of Canada's two national nuclear research laboratories. Situated on 4000 hectares of land along the Winnipeg River, Whiteshell Laboratories includes a number of major nuclear related R&D facilities, such as the Containment Test Facility, Hot Cells Facility, Irradiated Fuel Test Facility, Large Block Radionuclide Migration Facility, Radioiodine Test Facility, and Used Fuel Storage Containers.

Venue

Winnipeg, a city of 650,000 inhabitants in central Canada where the Canadian Shield meets the western prairies, is the gateway to Canada's most ethnically diverse province. A major Canadian cultural centre with a thriving community of literature, sport, music, ethnic organizations, religions, and art, Winnipeg is home to more than 43 different cultural groups that contribute to a distinctive tapestry of food, arts, entertainment, and hospitality. The CNS conference will coincide with Oktoberfest, which is a popular city festival.

Special Event and Guest Program

The conference will be hosted in the Westin Hotel, one of Winnipeg's finest hotels, connected by skywalks and underground walkways to the heart of the downtown financial and shopping districts. Special events during the conference will include a social evening with dinner and entertainment. A guest program of daily informal or structured outings will be available for accompanying guests who would like to see more of the city.

Call for Papers

The call for papers for the International Conference on Deep Geological Disposal of Radioactive Waste will be issued in **1995 May**. Four copies of single-paged abstracts in English will be requested by **1995 September**. Full papers will be required by approximately **1996 April** and will be published as refereed conference proceedings. Anyone interested in receiving a copy of the call for papers or wishing information concerning the conference, should contact:

1996 Deep Disposal Conference,
c/o K. Nuttall, Technical Chair,
AECL – Whiteshell Laboratories
Pinawa, Manitoba
Canada R0E 1L0

Tel. (204) 753-2311 / FAX (204) 753-2455
e-mail: WORONAS@URL.WL.AECL.CA

An Audit of the AECB – what it revealed

by Robert Polland

Ed. Note: Robert Polland is Director of Audit Operations in the Office of the Auditor General of Canada. He spoke to the CNA/CNS Winter Seminar last February on the results of the "value-for-money" audit of the Atomic Energy Control Board conducted by that Office in 1994. Following is a slightly edited version of his remarks. See also the AECB response by Patrick Banning.

Copies of the audit report on the AECB, which is Volume 10, Chapter 15 of the 1994 Report of the Auditor General to the House of Commons, can be obtained from the Office of the Auditor General of Canada, 240 Sparks St., Stop 10-1, Ottawa, ON K1A OG6.

Thank you for this opportunity to outline the results of the 1994 value-for-money audit by the Office of the Auditor-General of the Atomic Energy Control Board.

Before dealing with the audit results, let me explain why we chose to conduct this audit of the AECB – when we did – and how we selected the issues to be audited.

Our previous value-for-money audit of the AECB was completed in 1985. In that audit, we examined the management controls and administrative procedures connected with the AECB's licensing, inspection and enforcement activities. A follow-up in 1987 reported that the AECB had responded positively to our recommendations and was making progress in implementing them.

After nine years we thought it might be timely to take another look at the AECB.

How We Selected the Issues

Since none of the 1985 audit team members were still with our office, the 1994 audit team first had to familiarize itself with the AECB and the key issues involved in the regulation of the nuclear industry.

To gain this understanding, the audit team met with all AECB board members and all AECB senior management as well as other AECB staff.

We also spoke to over 25 AECB licensees representing a cross-section of AECB's business activities. In addition, we interviewed about 20 other stakeholders, including pro-nuclear and anti-nuclear groups, who were familiar with the AECB and nuclear regulatory issues. Almost all of the licensees and stakeholders contacted expressed a high degree of respect for the technical competence of AECB staff.

In the nine years since our last audit, many new pressures had been placed on the AECB as well as its licensees. These pressures included the federal regulatory reform which resulted in increased pressure:

- to reduce the number of regulations and any unnecessary duplication of regulations,
- to consult with interested stakeholders, and
- to assess fully the benefits and costs of regulations.

Other pressures included:

- the introduction of cost recovery in April 1990,
- the addition of a significant number of new AECB staff, coupled with the loss of a number of key and long-service employees,
- a worsening economic climate which led to a prolonged recession,
- age-related failures in the nuclear power plants, and
- increased expectations for protecting the environment.

The setting in which the AECB regulates the nuclear industry underwent major changes since our 1985 audit. These changes presented some significant and difficult challenges to the fulfilment of the AECB's regulatory obligations.

Our discussions with the AECB and other stakeholders helped us identify a number of potential audit issues. To assist us in prioritizing these issues, we assembled a group of advisors. These advisors consisted of both senior staff within our office, including the auditor general, as well as three external advisors, with expertise in the nuclear industry.

From this process, we chose to focus our audit on a few major issues which were considered to be of potential interest to parliament.

Our audit originally included an examination of the AECB's nuclear waste management regulatory activities. We concluded that, given the many players involved in dealing with nuclear waste, further audit work – beyond the scope of the AECB audit – was warranted. We are now in the process of concluding an audit of federal radioactive waste management. We expect to report on the results of this latter audit in the Auditor General's first periodic report scheduled to be tabled in May 1995.

What We Found – Overall Conclusion

Overall, we found that the AECB provides Canadians with assurance that the Canadian nuclear industry operates in a safe manner – while recognizing that the primary responsibility for safety rests with the user or licensee.

We felt, however, that even greater vigilance is required if the AECB is to continue to provide assurance that the industry remains safe. We concluded that without updated legislation and improvements in its management processes and practices, the AECB will be hindered in its ability to provide such assurance.

Some Specific Observations

Need for Updated Legislation

One of our concerns is that the 1946 Atomic Energy Control Act requires updating to reflect current circumstances. Its primary focus is on security of nuclear materials, *not* on health and safety. Yet the environment in which the AECB operates has changed immensely in the almost 50 years since the Act was passed.

For example, the Act does not provide the AECB with an appropriate range of enforcement tools to encourage compliance, the maximum penalty permitted under the Act is a $10,000 fine – which is not in line with other jurisdictions where environmental legislation and practices exist. Nor does the Act provide for any other administrative fines for failure to comply with regulatory requirements.

As well, the existing Act does not give the AECB explicit authority to require financial guarantees for the decommissioning of nuclear facilities or for the disposal of nuclear materials.

We felt that the weaknesses in the current Act have contributed to some of the deficiencies we observed in our audit.

However, new legislation by itself will not correct the deficiencies identified in the management processes and practices.

Deficiencies in Management Processes and Practices

Our findings have revealed that the AECB has many opportunities to improve its management processes and practices in such areas as:

- regulatory strategy and regulations,
- compliance and enforcement,
- jurisdictional issues, and
- human resource requirements.

To illustrate how these deficiencies can impact on the AECB's ability to regulate effectively, a few examples follow.

Regulatory Strategy and Regulations

We found that the AECB is making major shifts in the way it operates and regulates. In some areas, the AECB is moving toward becoming more prescriptive in its approach to the regulation of the nuclear industry. This means not only providing the "rules of the game" (telling the licensee *what* to do), but also providing more direction on *how* to do it.

We found that the regulatory strategy upon which these changes in approach are based had not been set out.

Also the AECB has not ensured timely completion and implementation of many of the projects initiated to update its regulatory requirements.

We recommend that the AECB should seek ways to expedite the handling and promulgation of regulatory documents as well as document more fully its regulatory requirements.

Compliance and Enforcement

A regulator must also have an effective compliance and enforcement function. That is, one which is enforced in a fair, predictable, and timely manner.

We found that the AECB had not yet developed up-to-date compliance and enforcement procedures and criteria for the areas we examined, namely, nuclear power plants, prescribed substances and radioisotopes, and transportation of nuclear materials. Without criteria, there is no basis for a common understanding of the regulatory requirements between the AECB and the licensee.

In addition, there were opportunities to improve the effectiveness of AECB's follow-up on non-compliance issues related to prescribed substances and radioisotopes.

We also reported on the inconsistent application of AECB's regulatory policy on decommissioning of nuclear facilities. At the time of the audit, the AECB had not yet established clear criteria for the requirements to be included in these decommissioning plans.

Jurisdictional Issues

Another area requiring improvement is the management of interfaces with other jurisdictions.

The AECB licensing system is administered with the cooperation of other federal and provincial departments in such areas as health, environment, transport and labour. We found that the AECB could more effectively manage the interfaces with these other jurisdictions through additional or more up-to-date co-operative agreements, and thus reduce the regulatory burden on taxpayers and licensees.

Human Resource Requirements

Human resource requirements is another area that requires review. In 1989, the AECB had stated that its resources were insufficient to enable it to assume its responsibilities fully. It identified a need for almost a 100% increase in its authorized staff level. At the time of the audit, it had received about 40% of the extra resources sought.

We found, however, that the AECB lacked an adequate basis upon which to properly assess its human resource requirements. It lacked a clearly documented regulatory strategy, strategic plan and workload assumptions.

Summary

In summary, without updated legislation and improvements in its management processes and practices, we believe that the AECB will be hindered in its ability to continue to provide assurance that the Canadian nuclear industry remains safe.

Concluding Remarks

I would like to add that the AECB has accepted all of our recommendations and has begun to address the issues identified in the audit. We intend to conduct a follow-up audit in 1996, but will also maintain periodic contact with AECB staff to obtain information on the status of its corrective action plans.

A response from Patrick Banning, Audit and Evaluation Officer, AECB to this report of the Auditor General's office follows on page 34.

Changes at the AECB – response to report by the Auditor General

by Patrick Banning

Ed. Note: Patrick Banning is Audit and Evaluation Officer at the Atomic Energy Control Board, a new position created in 1994. Previously he had been in a similar role at the RCMP.

The Auditor General made several observations as a result of the audit of the AECB. These observations can be grouped into two main themes:

1. the current Atomic Energy Control Act, proclaimed in 1946, requires updating to reflect current circumstances; and,

2. deficiencies in the AECB's management processes and practices that require attention.

It was found by the Auditor General that the present Act has contributed to some of these management weaknesses, but the AECB could, even in the absence of new legislation, improve upon its regulatory strategy, develop a strategic plan, provide better documentation of its regulatory requirements, and develop criteria for assessing compliance.

While still hopeful of receiving new legislation the AECB is not waiting for it to be proclaimed before taking action. After an extended period without a President, which may have contributed in part to the lack of direction, Dr. Agnes Bishop, who was appointed as President in September, 1994, has definitely taken charge. Using the Auditor General's Report as a stepping stone she has galvanized the AECB into a direction that will take us into the 21st century. I will elaborate on how this is being achieved.

The 1946 Atomic Energy Act focuses primarily on the security of nuclear materials, not on health and safety. The weaknesses referred to by the Auditor General that have had an effect on the AECB's ability to discharge its mandate include:

- the lack of clear authority to establish and enforce national standards for health, safety, security and the protection of the environment with respect to the use of nuclear energy in Canada;
- the absence of any requirement for financial guarantees for the decommissioning of nuclear facilities and the disposal of nuclear material;
- the inability of the AECB to take or order remedial action in case of an unacceptable hazardous situation, if there is no licence; and
- the need to bring the powers of compliance inspectors and the penalties for infractions in line with other environmental legislation or practices.

New legislation will improve the licensing process by incorporating licensing conditions into new regulations. Consultative documents will not be as complex and difficult to deal with as at present and we will eliminate the "R" documents. There has been too much confusion generated by the term "R" document.

Regulations

In July 1994, a Task Force was formed to draft updated regulations to meet modern regulatory standards and to incorporate numerous changes demanded by the quickly evolving nuclear industry. The Task Force was directed to amalgamate aspects of existing regulations and to draft new regulations, where required. As the project developed it was decided that the regulations should be drafted in such a way as to be appropriate for the new legislation but in the event of a delay, the regulations could, with very little additional work, apply to the present Act.

The Task Force's main objective is to draft regulations that are organized in a logical and coherent manner. Regulations will use simple language, minimize cross-referencing and reflect the nuclear industry's existing high security and safety standards. These requirements, together with extensive consultation and due regard for the government's well documented policy to ensure that regulators "regulate smarter" and not hamper the Canadian industry's competitiveness should result in a set of regulations that are simpler to apply, easier for the industry to understand and for which compliance can be monitored effectively.

A new policy relating to our compliance and enforcement function will ensure that the AECB will undertake reasonable measures to ensure compliance with the regulatory requirements established under the Atomic Energy Control Act in the interest of health, safety, security and environmental protection.

To obtain compliance the AECB will make use of two types of activity: promotion and enforcement.

The major promotional activities will be:

a. Public Consultation

To ensure that its regulations and licence conditions are clear, reasonable and capable of being complied with, the AECB will consult widely with the public and stakeholders.

b. Response to Inquiries

AECB will provide technical information and advice on the AECB's compliance expectations and the reasons for the various requirements. The AECB will also provide copies of the relevant regulations, regulatory documents and its compliance policy.

c. Explanatory Materials

Explanatory material such as application guides, safety posters, brochures and videos will be made available.

d. Notices

The AECB will issue notices to advise licensees and the public of items of general interest. These notices will include responses to common questions by licensees, common items of non-compliance that are being found during inspections, and notices of pertinent documents that are available.

e. AECB Reporter

The AECB Reporter, published quarterly, will be used to advise interested parties of significant items relating to compliance and enforcement.

f. Regulatory Guides

The AECB produces documents that provide explanatory material aid licensees of specify the AECB's compliance expectations. In some cases, these documents are referenced in the license conditions so compliance with the guide or equivalent performance will be necessary.

The major enforcement activities will be:

a. inspection and monitoring to verify non-compliance;

b. graduated response to items of non-compliance based upon the severity of the infraction and the past performance of the licensee;

c. investigation of violations;

d. measures to compel compliance without resorting to formal court action, such as; confirmation of corrective action, warnings, directives, directions by inspectors or licence sanctions; and

e. prosecution. Prosecution will be the normal course of action where one or more of the following criteria are met:
- the action put workers, the public or the environment at significant risk (major violation)
- a moderate violation was malicious or intentional;
- the violation, while not major, was repeated following notification by the AECB; or
- the violation was as a result of failure to respond to other enforcement actions.

This policy is still in the draft stage but it is being given priority and it is hoped that it will have public circulation soon.

Another Auditor General's observation was that the AECB should develop, and consistently apply, criteria for decommissioning plans for all nuclear facilities as quickly as possible. We expect to have available, for stakeholders comment, two 'C' Documents before the end of 1995.

The first document will be in the form of a Regulatory Guide to assist licensees in preparing their decommissioning plans. The guide will provide a framework for the systematic identification and strategic execution of the required decommissioning work.

The second document will be a policy statement and guideline on the release of materials and decommissioned sites from regulatory control. This initiative will attempt to standardize an approach for deriving release criteria in a manner similar to that currently used in calculating Derived Emission Limits for operational releases to the atmosphere and surface water.

The new proposed legislation will also be very useful for helping us to do business with other jurisdictions, not only other federal departments but also the provinces. The primary advantage of the new proposed legislation is that it will give the AECB the ability to reduce duplication and overlap with provincial officials, by delegating under the Act, activities that normally come under provincial jurisdiction such as labour, and conventional health and safety and the environment.

Under the joint regulatory processes the AECB has a memorandum of understanding with each federal and provincial agency that defines our cooperative programs. All of the Memorandums of Understanding will be reviewed to eliminate unnecessary duplication and overlap.

An area that always engenders a lively debate is the degree of prescriptiveness the AECB should take in its regulatory, compliance and enforcement activities. To some of our stakeholders we should be more involved in telling them "how to do it"; to others, all they want to hear is "what is required" and they will do the rest.

We have not reached a point that will satisfy everyone; and, perhaps it is not possible to achieve that state of perfection. However, the AECB will continue to work with its stakeholders to achieve a definition and understanding of what is acceptable given the complexity of activity, the experience with different technologies and the AECB's assessment of licensee competence.

The second theme in the Auditor General's Report dealt with identified deficiencies in the management processes and practices. It is important to note here that the Auditor General did not find any safety related issues and indeed remarked on the high degree of respect for the dedication, professionalism, and technical competence of the AECB staff as commented upon by licensees and stakeholders.

However, as he pointed out, if the AECB wished to continue to provide the people of Canada the assurance that the industry remains safe it will have to not only have updated legislation but improvements in its management processes and practices.

There is no simple algorithmic formula that can tell what number of people are required, performing which tasks to ensure that there is a very small chance of a very large accident from happening. This does not mean that we will not be working on the problem.

There are already several initiatives underway, and indeed some have been completed, in the program to match our regulatory strategy with workload assumptions and the necessary human resources to carry out our responsibilities. What makes the situation difficult is that we have just gone through a period of expansion and now, like all other government departments and agencies, must provide our share of budget reductions.

We are not just looking at numbers of human resources but included in the management strategy is a review of our organization to ensure that roles, responsibilities and accountabilities are clear to all, and resources required are defined, obtained and allocated to areas of greatest need.

Hopefully, this brief review gives you some sense of what the AECB is doing, not only as a result of the Auditor General's Report, which couldn't have come at a more opportune time, but also as a result of the AECB's analysis of what is required to meet the challenge of the industry, the government and the public "to ensure that the use of nuclear energy in Canada does not pose undue risk to health, safety, security and the environment."

NPT Review Conference Underway

On April 17, the Review and Extension Conference on the Treaty on the Non-Proliferation of Nuclear Weapons (NPT) began in New York.

The Conference is to decide on how, and for how long, the Treaty will be extended.

The NPT entered into force on 5 March 1970 for an initial period of 25 years. As of March this year there were 172 states party to the Treaty.

Over the past two years there have been four Preparatory Committee meetings to develop organizational arrangements and preparations for the Conference.

A review of the NPT has taken place every five years since its inception. This review is pivotal since the Conference must decide on whether or not there should be an extension of the Treaty and, if so, for one or more fixed periods, as before, or indefinitely.

The NPT has been the cornerstone of Canada's nuclear non-proliferation policy and Canada has taken an active role in all of the reviews of the past. This time Canada is in the forefront of countries urging for the indefinite extension of the Treaty.

The NPT divides countries into two categories, those with nuclear weapons (China, France, UK, USA, and the former USSR) and the others. The nuclear weapons states agreed not to transfer nuclear weapons or their technology while the non-weapons states agreed not to develop or acquire nuclear weapons.

The safeguards inspection system of the International Atomic Energy Agency was developed to ensure that weapons materials were not diverted from civilian activities to weapons use.

The NPT has been considered one of the most remarkable international treaties in that all of the signatory countries have given up some of their sovereignty in accepting IAEA safeguards inspections. It does not, however, contain any sanctions for violation of the terms of the Treaty. Rather, the concept has been to use the IAEA safeguards system to identify violations and depend on international reaction.

Canada's nuclear export policy, which was developed in the mid 1970s, requires recipient countries to be signatories to the NPT or an equivalent bilateral agreement and accept IAEA safeguards on their entire nuclear program. Most other major nuclear suppliers have followed Canada's lead. This approach has made the Treaty very effective in preventing the diversion of nuclear materials to weapons use.

There are still some countries with significant nuclear programs which are not signatories to the NPT. Most notable are India, Pakistan and Israel. North Korea, which had joined, withdrew. However, two long-time holdouts, Argentina and South Africa, have recently joined.

It is expected that the NPT Review and Extension Conference will continue for about two months.

AECL withdraws licence application to USNRC

In March AECL Technologies, the U.S. subsidiary of Atomic Energy of Canada Limited, asked the United States Nuclear Regulatory Commission to place its application for design certification of the CANDU 3 design on an indefinite hold.

It was just last fall that AECL Technologies submitted the CANDU 3 design to the USNRC for "design certification," a process developed by that agency to deal with most aspects of a design in advance of an actual project. The USNRC has a "cost recovery" policy (similar to that of the AECB) and informed AECL that the review wopuld cost about $50 million (US). That was considerably higher than the $20 million the Commission is charging General Electric and ABB Combustion Engineering for reviewing their new designs. USNRC noted that the review of CANDU would require more research because of their unfamiliarity with it and that some of the cost of reveiwing the US designs was being underwritten by utilities and the US Department of Energy.

AECL indicated that it might renew the application in the future.

BOOK REVIEW

Sophie's World

Sophie's World by Jostein Gaarder, Oslo, 1990, (English translation published by Phoenix House (Orion Press), London, 1994)

Reviewed by Keith Weaver

Every now and then, a book shoots to the top of the bestseller lists, and nobody seems to know why.

Robert Pirsig offered his book, *Zen and the Art of Motorcycle Maintenance*, to over 60 publishers before one accepted it. Even then, that publisher told Pirsig that he was accepting the manuscript only because it reminded him why he was in the publishing business in the first place, and that Pirsig should have very modest expectations, say total sales of about 3000 copies. Author and publisher both became rich on that one book.

In 1987, Allan Bloom published what was basically an academic book. The text bristled with nasty multiple syllable words (like "autochthonous"). Bloom was astonished to see the book climb to the top of the New York Times bestseller list and sit there obstinately for months. Few would have predicted that an academic's rantings about drifting too far from Plato and the collapse of American scholastic standards would have seduced the general reading public, but that's just what "The Closing of the American Mind" seemed to do.

If you start reading *Sophie's World*, you will immediately face about 150 pages of heavily didactic narrative about the work of ancient, medieval and baroque philosophers. In this roughly first half of the book, you will be effectively taking a philosophy course. Until, that is, you realise that there are odd things happening. It's not until you are about three quarters of the way through the book, that you will realise it really is a novel. (If you are like me, the subtitle "A Novel" on the front cover will be disregarded.) In the last 20 or so pages, you will wonder once again what kind of book you actually have been reading.

Sophie's World appears to have nothing at all to do with the nuclear business. The last place in the world one should expect to find a review of it is in the redoubtable organ you are now reading. Let me explain why the book was interesting to me.

I have read a book in which Aristotle was cast as a detective, and the author had him solve a murder case in ancient Athens. A book has been written in which St. Augustine is made to pronounce on the evils of technology. Camille Paglia calls upon figures in literature and philosophy to support the most astonishing statements, some of which have made feminists chatter and foam like bleed valves. But I have never, until now, encountered an author who believed that philosophy is vitally important to everyday people, and who demonstrated this belief by writing a book to show that it is true. Unfortunately, it seems to me that his book does not succeed in this. Large tracts of it are fairly stilted and do nothing more than provide narrative on the life and beliefs of philosophers. Admittedly, this narrative is readable, but it is not particularly interesting.

Throughout the book, the present day Nordic outlook on things environmental is evident. There are a few hints as to the ethical or philosophical implications of how we do things in the modern world, but they don't go beyond hints. Perhaps most interestingly, the internal coherence of an overall "philosophy" and its relevance to the world at large appears to diminish, to become unravelled, as we pass philosophers such as Hegel and Marx. It was disappointing, then, to find hardly a mention made of the overwhelming influence of science and engineering in changing the physical nature of our lives, and in fashioning entirely new paradigms by which we view and understand the world. (True, there was some discussion of clocks and the general fascination with "mechanism" about the time of Newton, but not a lot else.)

The last quarter of the book goes from odd to bizarre. This oddness overcomes any curiosity the reader might have in finding out how the author's interest in philosophy should be translated for general use today. On finishing the book, there is an almost palpable feeling of its oddness, its deflating strangeness; a sense of some new enlightenment, but tempered with some new confusion, a feeling of watching the rapid departure of a car, from which you have just been thrown into the ditch.

But the real burning question is "Why did all those people buy this book?" *Sophie's World* has sold like hotcakes in the countries of continental Europe and copies of it are now vanishing in the English speaking world. It is being translated into Turkish, Chinese and Korean. What did all those people get out of it? I would like to know. But I don't.

CALENDAR

1995

May 7-12 **International Conference on Isotopes**
Beijing, China
contact: Prof. Lin Qiongfang
Chinese Nuclear Society
P.O. Box 275-12
Beijing, China, 102413
Fax: 86-1-935-7195

May 8-12 **Two-phase Flow and Heat Transfer Course**
Hamilton, ON
contact: Betty Petro
McMaster University
Hamilton, ON
Tel.: 905-525-9140 xt 24881
Fax: 905-526-7104

May 16-18 **Annual Meeting on Nuclear Technology**
Nuremburg, Germany
contact: Dr. K.G. Bauer
INFORUM GMBH
Bonn, Germany
Tel.: 49-02-28-507-0
Fax: 49-02-28-5072-19

May 21-26 **Heat and Mass Transfer in Severe Reactor Accidents**
Cesme, Turkey
contact: Dr. J.T. Rogers
Carleton University
Ottawa, ON
Tel.: 613-788-5692
Fax: 613-788-5715

May 23-26 **CRPA Annual Conference**
Halifax, NS
contact: G. Mawko
Victoria General Hospital
Halifax, NS
Fax: 902-426-2018

May 28-June 3 **5th Topical Meeting on Tritium Technology in Fission, Fusion and Isotopic Applications**
Ispra, Italy
contact: Dr. H. Dworshak
Joint Research Centre,
Ispra, Italy
Fax: 39-332-789-108

May 29-31 **Topical Meeting: Managing Plant Life**
Nice, France
contact: Dr. Serge Charbonneau
Paris, France
Fax: 33-1-47.96-01-02

June 4-7 **CNA/CNS Annual Conference**
Saskatoon, SK
contact: Sylvie Caron
CNA/CNS office
Toronto, ON
Tel.: 416-977-6152 xt 18
Fax: 416-979-8356

June 12-13 **Workshop on Management and Operation of Nuclear Power Stations Using Computer Systems**
Fredericton, NB
contact: Jill Feero
NB Power
Fredericton, NB
Tel.: 506-458-3177
Fax: 506-458-4249

June 25-29 **ANS Annual Meeting**
Philadelphia, PA
contact: ANS office
Chicago, IL
Tel.: 708-579-8258

July 3-5 **20th Meeting of Latin American Section of ANS**
Rio de Janeiro, Brazil
contact: J. Spitalnik, Nuclen,
Rio de Janeiro,
Brazil
Tel.: 21-552-0945
Fax: 21-552-2993

August 4-6 **50th Anniversary of ZEEP**
Chalk River, ON
contact: Aslam Lone
AECL-CRL
Tel.: 613-584-8811 xt 4007

September ?? **CNA/CNS Fusion Seminar**
Toronto, ON
contact: Shayne Smith
Wardrop Engineering,
Tel.: 905-673-3788
Fax: 905-673-8007

September 10-15

NURETH-7 – International Meeting on Nuclear Reactor Thermalhydraulics
Saratoga, NY
contact: Dr. Michael Z. Podowski
Rensselaer University,
Troy, NY
Tel.: 518-276-6403
Fax: 518-276-4832

September 17-23

International Topical Conference on the Safety of Operating Reactors
Seattle, WA
contact: Dr. D.J. Senor
ANS, Richland, WA
Tel.: 509-376-5610

September 25-29

GLOBAL '95, on the Back End of the Nuclear Fuel Cycle
Versailles, France
contact: Dr. J.Y. Barre
CEA, Saclay Gif-Sur-Yvette, France
Fax: (33.1). 69.08.90.93

October 1-4

Fourth International Conference on CANDU Fuel
Pembroke, ON
contact: Mark Floyd
Chalk River Laboratories
Tel.: 613-584-3311 xt 3899

October 29 - November 2

ANS Winter Meeting
San Francisco, CA
contact: ANS office, Chicago, IL
Tel.: 708-579-8258

November 19-21

3rd Conference on CANDU Maintenance
Toronto, ON
contact: Mr. Tim Andreef
Ontario Hydro
Tel.: 416-592-3217
Fax: 416-592-7111

1996

February ??

CNA/CNS Winter Seminar
Ottawa, ON
contact: Sylvie Caron, CNA/CNS office
Toronto, ON
Tel.: 416-977-6152 xt 18
Fax: 416-979-8356

February ??

Plutonium Disposition with CANDU
Ottawa, ON
contact: John Luxat
Ontario Hydro
Toronto, ON
Tel.: 416-592-4067

February ??

CNA/CNS Student Conference
Ottawa, ON
contact: Sylvie Caron, CNA/CNS office
Toronto, ON
Tel.: 416-977-6152 xt 18
Fax: 416-979-8356

March 25-29

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

April ??

Conference on CANDU Fuel Handling
location TBA
contact: Ron Mansfield
Mississauga, ON
Tel.: 905-823-2624

May 6-8

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

June 9-12

CNA/CNS Annual Conference
New Brunswick
contact: Sylvie Caron
CNA/CNS office
Toronto, ON
Tel.: 416-977-6152 xt 18
Fax: 416-979-8356

July 21-26

ASME Pressure Vessel Conference
Montreal, PQ
contact: Dr. R.C. Gwaltney
Oak Ridge National Laboratory
Oak Ridge, TN
Fax: 615-574-0740

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 16-19

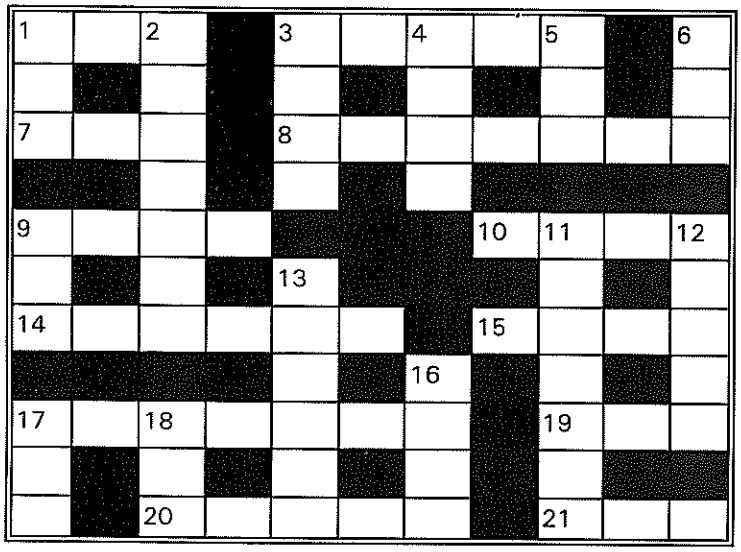
Deep Geologic Disposal of Radioactive Waste
Winnipeg, MB
contact: M.M. Ohta
AECL Research,
WL Pinawa, Manitoba
Tel.: 204-345-8625 xt 201
Fax: 204-345-8868

October ??

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

The Cross Section: No. 2

Easier



The solution is printed on the inside back cover page.

Clues

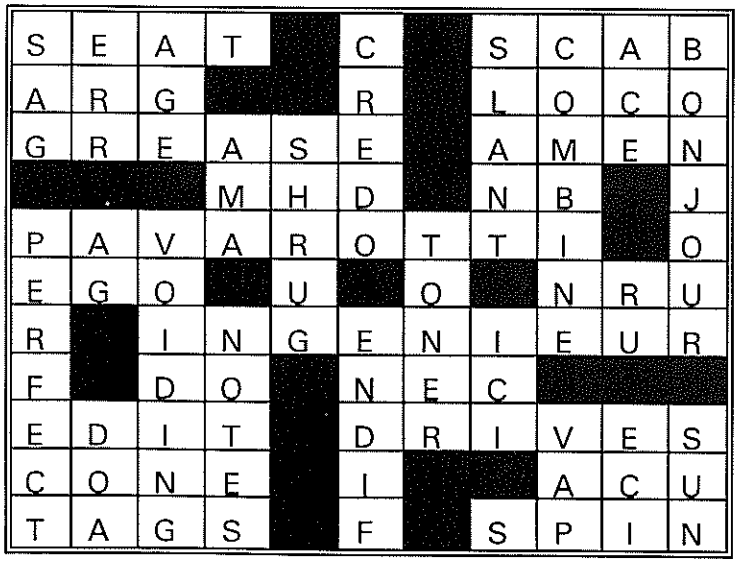
Across

1 Defect goes once round the track (3)
3 Pesto badly mixed down the mine (5)
7 Short aria is type of reactor accident (abbr) (3)
8 Device promotes gas-liquid contact (7)
9 Cheating on dole, but rich mother! (4)
10 American test body wears tams awkwardly (4)
14 Colour of uranium cake (6)
15 Mathematical term that sounds excremental (4)
17 Ted tore into four element valve (7)
19 Could be a lamprey (3)
20 Active gas that creeps into basements (5)
24 The long and short of it, a weight (3)

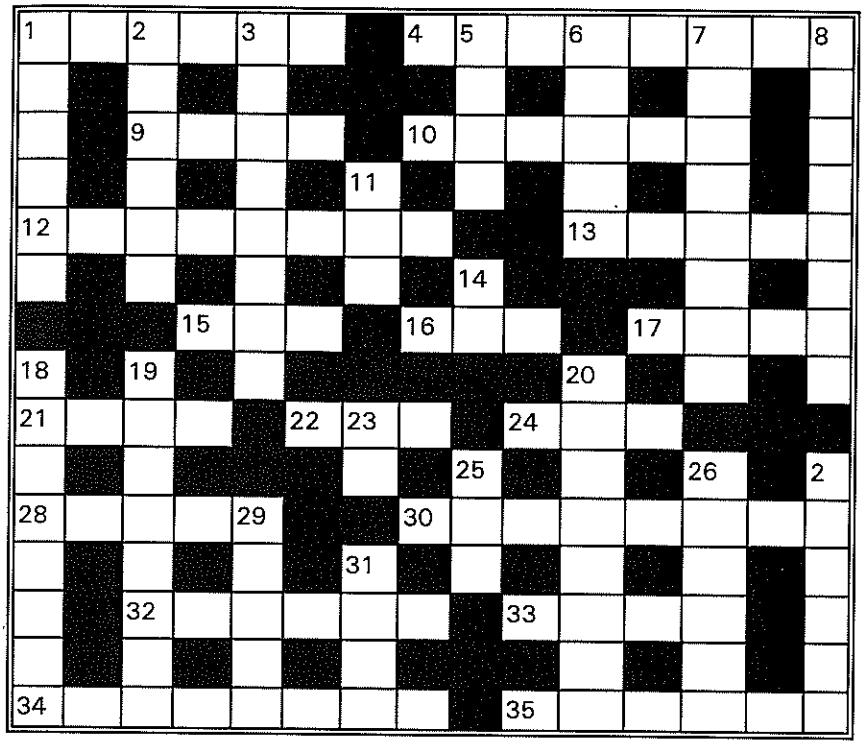
Down

2 Important number in fluid physics (7)
3 First shutdown system (4)
4 Gem stone in Palo Alto? (4)
5 Small amount of energy (3)
6 Off-site fuel storage (abbr) (3)
7 Switching device to renew patio bricks? (5)
11 Famous for t test (7)
12 Fashion mannequin describes phenomenon (5)
13 Doughnut-shaped (6)
16 Along with ball, describes type of hammer (4)
17 Threading device takes root (3)
18 Sheridan Park report series (abbr) (3)

Solution to Cross Section No. 1 (Easier)



Harder



The solution is printed on the inside back cover page.

Solution to Cross Section No. 1 (harder)

■	B	R	E	M	S	S	T	R	A	H	L	U	N	G
■	■	O	■	■	H	■	■	E	■	E	■	■	■	I
P	I	E	R	R	E	■	A	B	B	■	S	L	U	G
O	■	N	■	U	■	■	■	A	■	W	■	I	■	A
I	■	T	F	T	R	■	A	R	C	H	I	V	E	■
N	■	G	■	H	■	S	■	■	■	I	■	E	■	■
T	H	E	M	E	■	P	I	T	O	T	■	■	A	S
E	■	N	■	R	■	A	■	R	■	E	■	P	■	T
R	N	■	■	F	E	R	M	I	■	S	H	A	V	E
■	■	P	■	O	■	■	■	P	■	H	■	L	■	F
■	H	A	D	R	O	N	S	■	B	E	P	O	■	A
S	■	I	■	D	■	O	■	■	■	L	■	A	■	N
N	E	R	D	■	T	I	N	■	A	L	L	L	H	S
U	■	■	■	B	■	S	■	■	D	■	■	T	■	■
B	E	S	S	E	L	E	Q	U	A	T	I	O	N	■

Clues

Across

1 Computer used to draw and build (6)
4 Serb list conceals hydride sores (8)
9 Greek letter means little (4)
10 A nitro, mixed, is invitation to leave (6)
12 Nettoyage, en anglais (8)
13 Heating method, but just a hint (5)
15 Found in software and swamps (3)
16 Joan covers part of circle (3)
17 School children's dog comes out tops (4)
21 Amount of paper used on orifice (4)
22 Defunct terphenyllic reactor (abbr) (3)
24 Melba loses Spanish article, counts beans (abbr) (3)
28 Baseball play nabs downside (5)
30 A kelp bar yields dreary conversation (5,3)
32 Lightning inspires wireless operator (6)
33 Treat wounds in a tight spot (4)
34 Staplers modified for first aid (8)
35 Light bending devices (6)

Down

1 Take firm grip in changing gears (6)
2 Vehicle operator also instructs printer (6)
3 Element 89 (8)
5 Oral produces accident. Licensees rejoice? (4)
6 Work crew uses 1 Down (5)
7 U+PV (8)
8 Wise men emerge from Nat's pies (8)
11 Intersection operator (3)
14 Groan results in noble gas (abbr) (2)
18 Insult and good advice join at end of fissure (5,3)
19 Stamina's confused exponent (8)
20 Harsh manner is rough and wearing (8)
23 Scale-forming element accounts for tax (abbr) (2)
25 Can describe people and cheese (3)
26 Skilled workers profit from steady winds (6)
27 Shutdown nails iodine behaviour (6)
29 Compassionate core of French reactor (5)
31 One sweet drink disfigures fakir (1,3)

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COMPAGNIE / ÉCOLE / INSTITUT _____ ÉTUDIANT(E) ☐

ADRESSE DU BUREAU _____

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Téléphone (416) 977-7620

by George Bauer

It was about two years ago. The whole thing came to a head then, but I didn't realise at the time what was happening. Otherwise, I might well have invested in that vineyard outside Naramata, or taken up Bruce's offer to work the orange groves in the Blue Mountains.

The journals were piled up in an unsteady heap; the librarians were running hither and yon looking for pencils; someone from the EQ department was trying to pick his teeth with a CD. In short, a typical day at a large public electrical utility. I was there because I was researching an article on superconductivity and its application to symphony orchestras.

Anyway, I came across this short item in *Science*. It was an account of an interview with a former employee of Stellar Physics, a big player in the Superconducting Supercollider. He was discussing some of the things that caused him to leave the project and his employer of 17 years. He now works for Smith & Wesson. ("It's more satisfying. It makes less noise, and a lot less heat, and there's actually a chance of hitting something.") It wasn't his employment status that interested me though, nor his insights on ballistics. What he had to say about Einstein was most rivetting.

Harry, (he was identified only by that moniker) had a soft spot for old Albert. Had studied everything he could find about him since he (Harry) was a boy. So it was a bit disturbing for him to come across some chap poking around, *very critically*, in Einstein's work.

What was this chap looking for? Harry asked.

"Mistakes."

A short discussion followed. Eventually, Harry went away in some turmoil. Mistakes indeed!

The next morning, Harry awoke with a determination to get to the bottom of this "mistakes" business, so that he could put it behind him. So he asked around. What he found was that there were other people who had been flustered as well. He found out that the fellow's name was Anderson, Quentin Anderson. He had come to the project from the NRC, where he had worked briefly. Prior to that he had spent two years with the AECB, and before that he had been an inspector with the Department of Fisheries and Oceans in Halifax, counting fish.

Harry spoke to his boss. The response puzzled him even more.

"Stay away from Anderson. Let him get on with his job. He has important work to do."

"Can you tell me what it is?"

"He's looking for mistakes."

"Mistakes?"

"Yes. Mistakes. Errors. Screws up. Faux pas. Falsche Schritte. Things not right."

Back in his office, Harry sifted through this answer, hunting for the intelligence that evidently lurked in it. It all proved too subtle and elusive for him, and after half an hour he headed off to the cafeteria. Lo, there he was. Anderson. At a table all by himself. Harry quickly grabbed a coffee, came over to Anderson's table, introduced himself, and took a seat. They exchanged politenesses and identified the general frustration with weather prediction as the source of the western world's problems, before getting down to the real business.

"So what are you working on", Harry began.

Anderson took a long sip of his coffee, apparently to collect his thoughts. Looking closely at Harry, he said, "My work is something I don't often discuss. It's not particularly secret or sensitive, at least in the usual sense, but it seems to be misunderstood very easily. Whenever I try to discuss it with anybody, I usually wind up in an argument." Clearly, he would need a bit of drawing out.

"Try me," Harry offered.

They began talking about Einstein, and an idea Anderson had while he was at university. He couldn't bring it to a conclusion then, and had let it lapse after he went out to work.

"It was when I joined the NRC that the whole thing was revived," he said. "They were very interested when I explained my ideas to them. They encouraged me to start right away."

"What was it exactly that you were looking for," Harry probed.

Anderson took a deep breath and fixed Harry with a steady gaze. "I think Einstein was wrong. I'm looking for ways to check his work. In particular, I'm not convinced that the exponent in his formula for the conversion of mass to energy should be two."

They discussed the subject at length, but Anderson wouldn't budge. It was a week later, after much thought, that Harry made his mistake. He wrote an article for *Physics Today*, entitled "Was Einstein Wrong?"

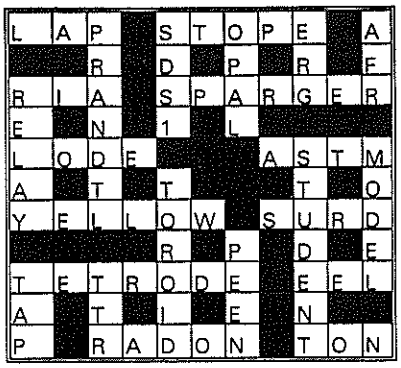
It never saw the light of day. Several days after he submitted it, two burly chaps turned up at his office door one morning. Said they wanted a chat. In their office. Their office was on the other side of town. They asked why he wanted to know about Anderson. "Because I'm a friend of Albert Einstein," Harry replied. They asked where this Einstein lived. It all went downhill quickly.

I finished reading the interview. In the months that followed, its significance became clear. It's safe to say that Anderson's work has had a huge effect on my life. It's not just his fixation with Einstein; it's rather his enormous success at selling this fixation and generalising it over other topics. The first day it all became clear to me one day was when I was shelving some old documents that were unreadable and that nobody ever looked at anyway.

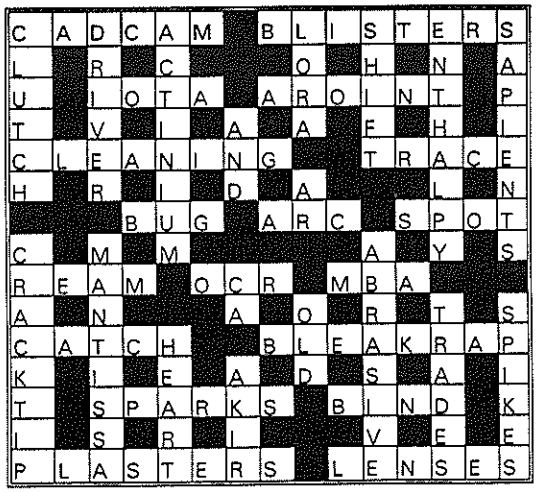
The letters virtually leapt out at me. That's it, I said to myself! Quentin Anderson. QA!

Solutions to The Cross Section, No. 2 (pp. 40-41)

Easier



Harder



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