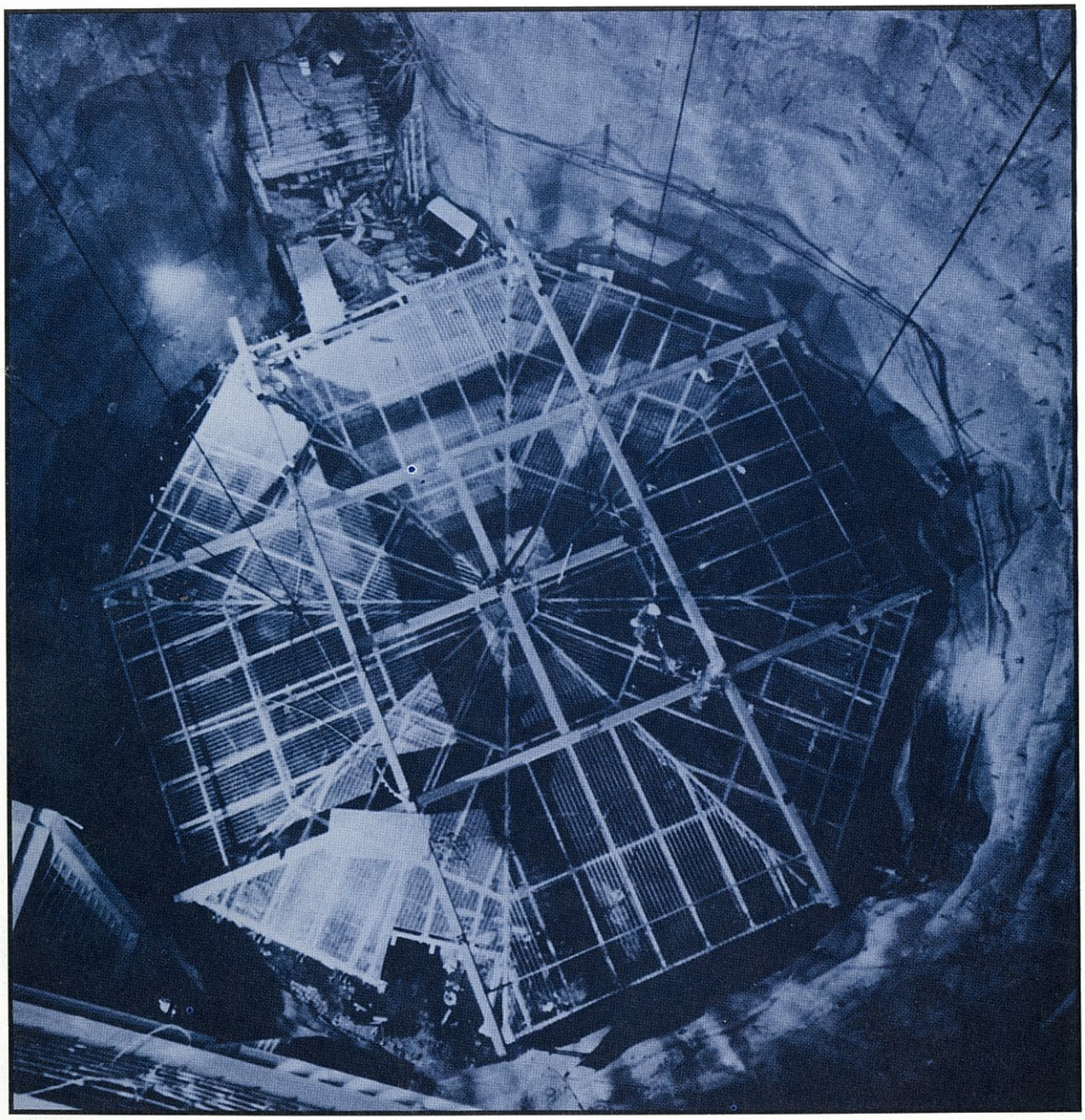
CANADIAN NUCLEAR SOCIETY

bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

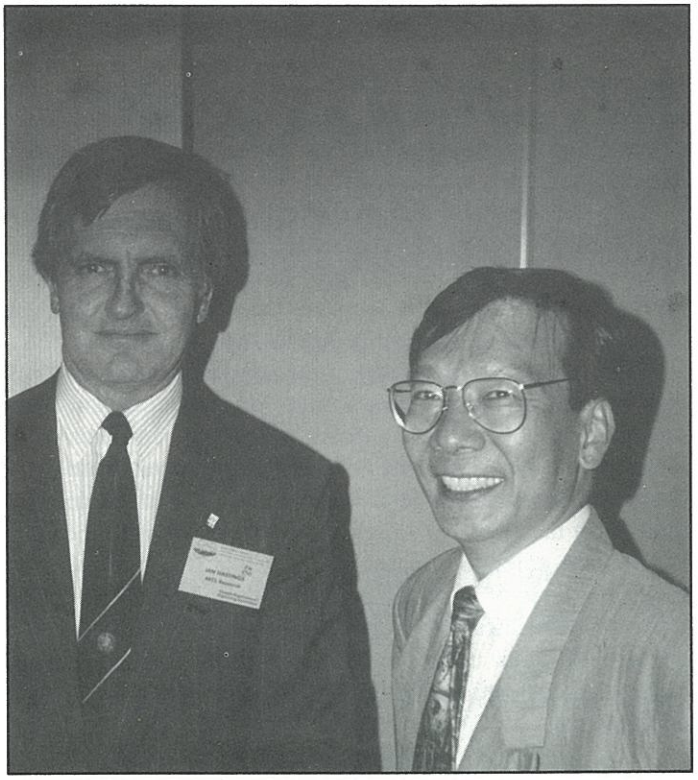
SUMMER / L'ÉTÉ 1994

VOL. 15, NO. 2

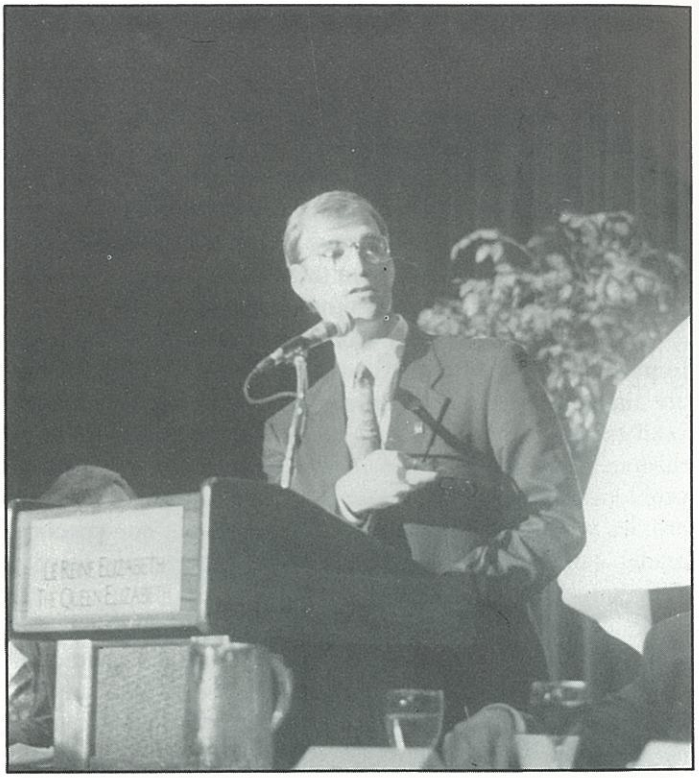


- Nuclear Waste vs. Garbage
- Sudbury Neutrino Observatory
- CNA/CNS Annual Conference
- 2nd Steam Generator Conference

CNA/CNS Annual Conference

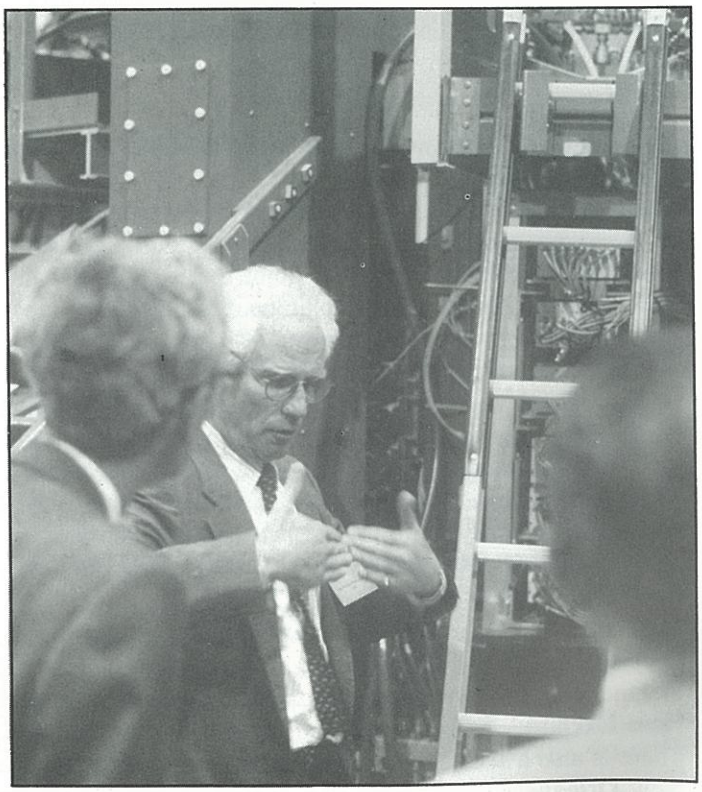


Ian Hastings and Hong Huynh co-chaired the successful 15th CNS Annual Conference held in Montreal, June 5-8, 1994.



Astronaut Mike MacKay speaks at the CNS luncheon June 7 during the CNA/CNS Annual Conference.

Paul Fehrenbach passes over the reins to incoming president Ed Price at the CNS Annual General Meeting in Montreal, June 7.



Richard Bolton explains a feature of the Varennes tokamak during the technical tour at the end of the Conference.

A waste crisis – two perspectives

by HANS TAMMEMAGI

Oakhill Environmental

1. Introduction

The disposal of high-level nuclear waste is perceived by many to be an unsolved dilemma which stands square in the path of continued nuclear energy production. It appears that radioactive wastes are so noxious and so hard to contain that scientists simply cannot figure out how to safely dispose of them.

Rather than looking at this problem as an isolated case, perhaps it would be useful to see how other wastes are being managed. After all, looking at other peoples' problems often helps put our own into perspective. Let's start with a look at regular household garbage. Municipal solid waste and nuclear waste at first sight seem as different as night and day. The former is hauled benignly from the curbside every week, and the latter is seen as a toxic demon's brew generated by nuclear power plants. Yet both are unwanted byproducts of our society's lifestyle. Since society has been dealing with municipal waste since Adam threw away the apple core, there must be some lessons that the nuclear sector can glean in their quest for safe disposal.

2. Municipal Garbage in New York

Let us begin with a brief look at the historical development of municipal garbage disposal. New York City is one of the largest municipalities in the world and deals with monumental volumes of household garbage every single day. Where does this go? How is it managed? What can the nuclear energy business learn?

An excellent review of the history of waste landfilling in New York is provided by Walsh (1991). Before the turn of the century, New York's solid waste was simply dumped at sea. This proved a cheap and convenient solution until beachfront communities began to protest against the frequent washing ashore of garbage.

The solution was found in 1895 in New York's first comprehensive waste management plan. Instead of being towed to sea, barges laden with garbage were taken to landfills located on tidal wetlands skirting the ocean. This was considered a good solution at the time because tidal wetlands were abundant and were thought to be of little value. Rather than being concerned about the environmental fate of wetlands, filling of marshes was felt to be beneficial in improving the economic value of these lands.

Interestingly, the 1895 waste management plan included an intensive recycling program for paper, wood, metal, cloth products, and food waste. This lasted until approximately 1918, and was not revived until the current wave of recycling and blue boxes.

After the first world war, the volume of waste increased by 70% with annual waste generation exceeding 15 million yd^3. To accommodate this waste load, new landfills were opened throughout the City and by 1934, 89 truck-accessed landfills were operating in New York City. As the population continued to grow and the geographic limits of the City expanded, it became more and more difficult to site new landfills, and the existing ones came under increasing pressure to operate cleanly, or to close altogether.

2.1 Emergence of the Dreaded NIMBY Syndrome

To this point, landfills, being only a few feet thick, had all grown horizontally and thus, consumed large tracts of land. This growth, along with the inherent dirtiness of landfills, inexorably lead to a conflict with urban development. In 1949, for the first time, the height of landfills in New York was increased to create additional storage capacity. This trend to vertical growth has become a cornerstone of today's municipal landfills.

However, the conflict between municipal development and landfills continued to worsen and a social phenomenon developed which today is known as the **NIMBY** syndrome (Not In My Back Yard). Because of vocal opposition, the number of landfills in New York City diminished steadily from 89 in 1934 to a single one in 1991. The lone survivor, the Fresh Kills Landfill, is understandably, gargantuan in proportion. It covers 3,000 acres and, as its expansion in the horizontal direction has been constrained, has grown to the amazing height of 500 feet.

Today, New York has placed itself in a very vulnerable position. It is totally reliant on the Fresh Kills Landfill, which is increasingly becoming a target of environmental concern. There is now an awareness that considerable environmental damage is caused by

landfill leachate. In addition, the inherent value of wetlands and the importance of preserving them is now recognized.

So this leaves New York in a garbage crisis: NIMBY will not let them site new landfills, environmentalists will not let them operate incinerators, recycling can divert but a small fraction of the waste (and that with a significant economic penalty). While the crisis festers, the landfill grows taller and taller. The Fresh Kills Landfill is destined to become the highest point of land on the eastern seaboard!

"[New York's only landfill] is destined to become the highest point on the eastern seaboard."

Unfortunately, this scene is not isolated. On the contrary it is typical of municipal landfills throughout North America. As the number of landfills decreases, their height grows and they cast a long, dark shadow across the land.

3. Comparison of Municipal Solid Waste to Nuclear

3.1 Environmental Impact of Landfills

It is important to realize that both nuclear waste and municipal waste have the potential for serious health and environmental impacts. To understand this issue we must recognize one unassailable fact: ***even state-of-the-art municipal landfills with double liners and other modern leachate containment systems will fail eventually***. This fact is recognized by the companies that design and build landfills as well as by the US Environmental Protection Agency (Lee and Jones, 1991). The length of time for such failure to occur is in the order of a few tens of years. In fact, many landfills begin to leak even before they are permanently closed.

So what will happen? The answer is simple: landfill leachate will leak out and contaminate the groundwater. This has serious consequences because landfills are generally situated close to the cities they serve and, hence, also close to their water supplies. The EPA estimated that there are about 75,000 sanitary landfills in the US and that more than 75% are polluting groundwaters with leachate (Lee and Jones, 1991).

"The contents of municipal landfills are by no means benign."

The contents of municipal landfills are by no means benign. In addition to grass clippings and old newspapers there are oven cleaners, batteries, finger nail polish remover, oils, solvents, and other toxic materials. Although the implementation of "household hazardous days" is diverting some of these hazardous substances to proper treatment and disposal, a substantial portion slips through the net. In addition, there is the accumulation of such materials from earlier years. These substances contain chlorinated organic compounds such as vinyl chloride and trichloroethylene as well as heavy metals including copper and lead. Vinyl chloride can cause liver cancer and neurological disorders and lead can damage the nervous and reproductive systems (Parmeggiani, 1983). These chemicals are every bit as nasty to humans and the environment as radioactive wastes.

3.2 Physical Size of the Problem

A major difference between nuclear and household garbage is the physical size of the problem. The amount of nuclear waste is many thousands of times smaller in volume and is thus much more amenable to management, including treatment. All the high-level radioactive waste generated in Canada well into the next century can be fitted into one repository i.e. nuclear landfill (Dormuth and Nuttall, 1987). This is very important since it makes the problem a more manageable size, and allows a centralized approach to be taken, assuming our fragmented Canadian political system has the will to do so.

3.3 Depth of Burial

Geological disposal will place nuclear wastes deep underground, not on the surface where erosion and weathering can attack and deteriorate landfill barriers and result in impacts on surface waterways and air. This is a fundamental difference, as Canada is blessed with geological formations that have been stable for thousands of millions of years and it can be predicted with some confidence that they will retain this stability for eons to come. Deep isolation is far superior to near surface disposal which is not only accessible to the elements, but also to human curiosity and intrusion. The disposal of wastes, of whatever kind, will be considerably safer deep underground, in carefully selected locations, rather than in surface landfills near urban centres.

3.4 Packaging of Wastes

The approach to packaging municipal and nuclear wastes is quite different. Nuclear wastes will be packaged in leach-resistant containers made of copper or titanium and then surrounded by buffer and backfill materials. A systems approach using a multi-barrier concept is being considered which will be compatible with the geochemistry of the surrounding rocks and groundwater (Johnson et al., 1987). In contrast, municipal garbage is effectively placed in the landfill as is. With the current landfill crisis, efforts are being made to remove those components that have some value to society. However, the remainder is dumped unceremoniously into the landfill in the form in which the householder has disposed of it.

3.5 *Regulatory Approach to Safety*

Another interesting difference between the two types of waste is the regulatory approach to safety. The two types of waste answer to two different regulatory bodies, who have taken two very different paths. The federal Atomic Energy Control Board (AECB) requires that nuclear waste must be disposed in such a manner that the risk of a fatal cancer or serious genetic effect to the most exposed nearby resident is less than one in a million per year (Atomic Energy Control Board, 1987). This safety target has been established based on international consensus reached through established and recognized scientific groups. To ensure that this requirement is met, the nuclear industry is required to *quantitatively* assess the impact of a nuclear waste disposal facility. The risk assessment is complex, thorough, involves probabilistic computer analyses, and analyzes the potential path of the contaminants from the nuclear landfill through the groundwater, biosphere to the most exposed individual.

"No risk assessment or calculation impact [of non-nuclear waste] is involved."

The safety standards for municipal landfills in Ontario are based on prevention of groundwater contamination (Government of Ontario, Regulation 347 under the Environmental Protection Act). In turn, "contamination" is defined by comparison to background levels (MOE, 1986). The basic principle is to protect existing and potential reasonable uses of water (MOE, 1986). The primary tool for ensuring compliance is monitoring of groundwater around and adjacent to landfills. No risk assessment or calculation of impact on humans or the environment is involved.

3.6 *Sustainable Development and Future Generations*

A principal difference in the approaches to nuclear and municipal waste is in the consideration of future generations. For nuclear, it is a regulatory requirement that disposal methods be found that meet the specified safety criterion without relying on long-term institutional controls (AECB, 1987), that is, without placing a burden on future generations.

In contrast, landfills in Ontario do not have to predict any future, i.e. post-closure, impacts. There are no specific closure regulations but guidance manuals describe requirements for a surface cap and long-term monitoring (MOEE, 1993). The Minister of Environment and Energy's approval is required if a landfill site is to be used for other purposes within 25 years of its closure. There is also a requirement to maintain engineered works such as leachate collection systems as long as needed. Given the near-surface situation of municipal landfills, this could be a long time. In other words, the municipal garbage system passes the buck to our children and their children.

It is interesting that in discussions of maintaining municipal monitoring and leachate collection systems, the period of time is usually considered to be a few tens of years, or at the most pessimistic, a few hundred years. At no point are thousands or tens of thousands of years mentioned, as they are for nuclear wastes. This is very short-sighted as heavy metals and other inorganic substances do not decay at all with time. An appropriate analogy is that organic compounds in municipal waste, which degrade with time (over tens and hundreds of years), could be compared to the shorter-lived radioisotopes such as fission products, whereas heavy metals and other inorganic compounds are similar to the longer-lived nuclear transuranic elements with both, for all practical purposes, having infinite half lives. Municipal waste management does not address the long-lived component.

The vertical growth of landfills makes it very difficult for landfill operators to exhume wastes and make repairs. In other words, modern landfills with their emphasis on vertical growth are designed so that it would be very difficult or impossible to make repairs to liners and associated underlying structures.

Furthermore, perpetual care would be required as any repairs would last only a few decades and would need to be repeated periodically *ad infinitum*. Put very bluntly, municipal and industrial landfills are designed and regulated to give the problem to future generations! We are getting a cheap service today, but our grandchildren will bear the cost and responsibility of looking after these landfills and/or drinking the leachate-contaminated groundwater.

A cornerstone in today's political thinking, including that of the Canadian federal government, is "sustainable development" (Government of Canada, 1990). In simple terms, sustainable development is about human beings acting in a responsible manner so our grandchildren will also have a nice planet to live on, and so will their grandchildren, etc.

Passing the landfill buck to future generations flies directly in the face of sustainable development. The federal government has pledged to make Canada a leader among nations in promoting sustainable development. Somehow this message hasn't trickled down to the municipal and provincial levels of government who are responsible for municipal landfills.

3.7 *Siting of Disposal Facilities*

In this sea of contrasting management of nuclear and municipal wastes, there is one island of similarity: it is incredibly difficult to find disposal sites for either of the waste types. To avoid making unpopular choices, politicians are delaying and delaying.

For municipal wastes in Ontario, an elaborate procedure called "Master Planning" has been established whereby a landfill has to be considered as part

of an overall system of recycling, waste minimization, and disposal. A formal multi-staged process has been defined by the Ministry of Environment and Energy of which a cornerstone is the empowerment of the involved citizens. Needless to say, a process which at every turn must consult the public and be sensitive to, and incorporate, its feelings, will be cumbersome and, given the dreaded NIMBY syndrome, ineffective.

This has indeed proven to be the case, with the Ontario taxpayer paying vast sums of money, yet seeing little forward progress.

The nuclear scene is facing the same dilemma. Politicians, afraid to take any step forward, find every excuse to delay progress. The AECL and Ontario Hydro research program into disposal has been active since about 1975. Now it is being subjected to the most massive and costly environmental assessment ever held in Canada. Not only is this hearing going on and on and on (it is already in its fourth year with no end in sight), but it is doing so in ivory-tower isolation. For example, internationally renowned scientists are quibbling about whether the microbes that might be found 500 m underground might cause generation of gas (Environment Canada, 1992). Whether such gas would impact the integrity of a disposal system is not known, but the "experts" feel that an understanding of the microbes (if any) is critical to the safety of nuclear disposal.

Other similar scientific matters are being studied with a painful academic thoroughness. However, in their microscopic review of the vascular tissue that forms but a small part of the bark of a lonely tree, somebody has forgotten that there is a forest out there. The Federal Environmental Assessment Review Panel (FEARP) terms of reference do not include a comparison to how our society manages other wastes (FEARP, 1992). The process is enmired in itself and cannot see outward.

4. Closure

Nuclear waste and household garbage are very distinct and different waste types. Their physical characteristics differ and, even more dramatically, the approaches that are being taken for their disposal lie at opposite ends of the spectrum. And industrial landfills, of which there are thousands, and which contain a myriad of dangerous materials, have been ignored. In Ontario industrial landfills are designed and regulated in much the same way as municipal landfills.

All these wastes are being generated on an ongoing basis by our society and they must be managed and disposed in a manner that does not harm humans or the environment, either today or in the future. That is, society's wastes must be managed in a way that embraces the concept of sustainable development. Sustainable development is not just about preserving natural resources, it also involves the backend of the industrial cycle.

Rather than treating each of these waste types in separate isolated compartments, there should be an integration of the principles and regulations involved in their management. Society and the environment will benefit by sharing technology and having common health and safety objectives for all waste types.

"Management of nuclear waste is more advanced in technology and more rooted in the principles of sustainable development."

We started down this path by looking for lessons that the municipal solid waste disposal process might offer nuclear. Instead, we have seen that the management of nuclear wastes is more advanced in technology, and most importantly, has its philosophy and technical approach to disposal more firmly rooted in the principles of sustainable development.

Perhaps our society should step back and put nuclear in perspective with other wastes and integrate the regulatory and management practices of all waste types. The waste industry can learn much from the nuclear approach.

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Quality culture from a marketing perspective

by S. AHMED HASNAIN

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Abstract

Quality culture is the highest level in a hierarchy of cultures, as quality may be made to represent whatever the customer wants, be it safety or social grace. Marketing concepts are applied to explain quality and to sell it to professionals.

Introduction

Quality considerations today enter every field of human endeavour. Achievement of the highest quality provides a competitive edge and is the key to success in a market economy. Pursuit of quality pervades all levels in organizations until it becomes part of the organization culture.

Every field has its own definition of quality. In engineering, what began as quality control in making goods to standard specifications grew into sophisticated techniques of quality assurance. In management and other social sciences, difficulties in measuring qualitative factors such as human preferences led to the concept of continuous quality improvement (CQI). At the highest level in every field, Total Quality Management (TQM) has become the tool of choice for success.

Unfortunately, there are wide variations in the way quality is practised. In some sectors the idea of quality is not embraced uniformly by workers. Quality assurance or performance audit is sometimes considered to be interference in the autonomy of skilled practitioners. Professional engineers or physicians traditionally put their own seal on their work and may resent the suggestion of an independent quality audit. On the other hand, many decision makers consider TQM as a buzz word, having a good sound but not much practical utility.

We have found it useful to apply concepts of marketing in making quality assurance more acceptable at the working level and in selling TQM to executives.

Ubiquitous Customer

The key concept is that of the ever-present customer. Modern business considers every human interaction to consist of an exchange of value. One participant gives, the other receives; the giver receives payment. Each is a giver and a receiver. There is an exchange. Both participants are customers of each other. The utility or quality of all human exchanges, or goods bought and sold, is only in the eyes of the customer of the moment.

Quality Defined

A widely accepted definition of quality in a market economy is, therefore, based on the nature of a product or service that meets the needs of the customer. The International Organization for Standardization defines quality as "*the totality of features and characteristics of a product or service that bear on its ability to satisfy stated or implied needs*". Use of the word "implied" places the control squarely in the hands of the customer whose needs are to be satisfied.

An endless variety of customers and their changing needs require quality to take on different forms. The required quality of a service or of a product is specified by the ultimate consumer or customer. For example, a space vehicle may be subject to exacting specifications during construction and operation in order to achieve a sufficiently low component failure probability. On the other hand, a heart surgeon relies mainly on professional integrity and skill as guide in a new kind of organ implant. For most art forms such as music, the only judge is a discerning clientele.

For most engineering tasks, fortunately, the required quality standards can be specified in measurable terms. Professional bodies develop technical requirements. National standards organizations provide legal cover. Internationally, the ISO 9000 series of standards for quality management are rapidly being adopted. They provide quality assurance through objective evidence of effective adherence to documented quality plans.

Quality is harder to define in areas involving human interactions. These are generally not measurable. Some aspects may only be described qualitatively by each individual in personal terms. Yet there is never any doubt about what is acceptable or better. In such cases, where quantitative measurement of traits is not possible, success demands continual attention to details so as to supply the best possible product to the customer.

An entire discipline of Continuous Quality Improvement has evolved that encompasses both measured and intuitive quality. It is based on analysis of a production process by breaking it down into

discrete steps, defining the purpose of each, simplifying, improving and standardizing, with provision for continual review. It seeks to prevent faults before they occur, for a goal of zero defects. This contrasts with the conventional scope of quality control, that inspects a product after manufacture, or checks a person's work. Such inspection not only amounts to duplication of effort but may be considered offensive by the producer whose work standards are challenged. For this reason, QC/QA exercises are often resisted by professionals. They call it the policy of "bad apples". It corresponds to McGregor's management Theory X, according to which workers cannot always be trusted. They must be policed and their work must be checked. The contrasting Theory Y would trust workers and not rely on inspection. In that spirit, CQI prevents errors by building in quality, instead of correcting mistakes afterwards.

The next refinements in quality are Total Quality Control (TQC) and Total Quality Management (TQM). They introduce teamwork to the exercise. Getting inputs from all levels and building consensus helps develop a sense of ownership in the product among all workers, resulting not only in quality improvement but also greater job satisfaction.

Hierarchy of Quality

In fact TQM represents the apex in the development of quality management, illustrated as a hierarchical succession below. Beginning with quality control at the lowest level, the first step in the ladder is quality assurance. Successive steps lead up to CQI and TQM.

```
TQM
 ↑
TQC  –  Participative Management Style Y
 ↑                                (McGregor)
CQI
 ↑
Product Line Management
 ↑
QA
 ↑   – "Bad Apples" – Management Style X
QC                        – Policing
```

In addition to the correspondence with management styles X and Y, another analogy is seen with Maslow's hierarchy of needs. Just as the needs theory finds a progression from the basic needs of food and shelter up to social needs of recognition and self-actualization, so does increasing quality raise social conscience to the level of participative teamwork, to the extent that it becomes a quality culture.

Quality Culture

We notice that there also exists a hierarchy in organization cultures, with quality culture at the highest level, as illustrated below. The basic but most primitive culture is social. Finance people advocate a cost culture to permeate the organization. Space and nuclear engineers emulate a safety culture.

```
Quality Culture        Any customer
      ↑
Safety Culture         Customer = Safety
      ↑
Cost Culture           Customer = Cost
      ↑
Social Culture         Customer = Society
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A quality culture encompasses all these and more, if we define quality in its modern sense: "*whatever satisfies the customer*". Changing the customer as needed allows quality culture to represent any one of the lesser cultures.

The attractiveness of the concept lies in transforming the ubiquitous customer to the highest level and making quality synonymous to the highest culture. The analogy can be helpful in selling quality to engineers and other highly educated people. They might more readily buy the philosophic message than the mundane benefits of quality.

Marketing of Quality

All professionals, executives and middle management, would accept the essential point of marketing that everyone is a customer as well as a provider: we give something to get something. Every human exchange is a sale. Quality consists in fulfilling the needs of the customer in the exchange. Customers may be external: buyers, regulators or standards bodies. They may be internal: one department or person providing a service to another, e.g. the boss serving the subordinate by providing a job to him, whose quality is judged entirely by the subordinate based on his own measures of return of money or job satisfaction. In a competitive environment, all participants must position themselves as high-quality providers, as defined by their customers, in order to attain a greater market share than their competitors.

Traditionally, the main customer is the buyer. We are trained to meet their needs of quality. But a more important "customer" may be the government or other payor. All possible customers and their needs must be analyzed and continuous effort made to satisfy them.

Internal customers may be harder to identify. Marketing methods can help us here also. In all our human interactions at work or play, we continually deal with colleagues, friends, the boss or subordinates in exchanges of value. Success demands that we recognize the needs of these internal customers, define them, and then deliver more than each customer expects, to achieve a happy working or leisure environment.

Conclusions

In the pursuit of higher quality the concept of Quality Culture as the highest in a hierarchy of cultures can help in greater acceptance of the discipline required. Marketing methods are effective if quality is defined as the needs of the customer, whether external or internal.

Observing the Sun from two kilometres underground

by E. DAVIS EARLE

AECL Research, Chalk River Laboratories

Ed. Note: *One of the very few papers given at the CNA/CNS Annual Conference in June not dealing with nuclear power, and one of the most interesting, described the Sudbury Neutrino Observatory. Dr. Davis Earle pointed out that he was presenting this paper on behalf of many people and organizations involved in the construction of this unique facility. If this short paper whets your appetite more information can be obtained from Education Officer, Laurentian University, Sudbury, Ontario, FAX 705-675-4868.*

Introduction

The Sudbury Neutrino Observatory (SNO) will make a major contribution to solar neutrino research. The civil construction work for the observatory is complete and the installation of the scientific components will begin after the Inco summer shutdown. The results from other solar neutrino experiments show a significant deficit of electron neutrinos as compared to theoretical predictions. In addition, measurements of the neutrino energy spectrum suggest that the electron neutrinos produced in the sun may be changing to another type enroute to earth. SNO's relatively high sensitivity to neutrinos and its unique sensitivity to all neutrino types make it an ideal observatory for checking models of solar burning, for answering the fundamental question of a neutrino mass and for observing supernova in our galaxy.

SNO is being built in Inco's Creighton Mine near Sudbury and will use 1000 tonnes of heavy water, on loan from AECL, as the neutrino detection medium. SNO has been funded by the Natural Science Engineering Research Council, the National Research Council, Industry Science & Technology Canada, the Northern Ontario Heritage Fund Corporation, the U.S. Department of Energy and the U.K. Science & Engineering Research Council. It has been designed and built with the help of Monenco-Agra and will be operated by an international team of 60 scientists under the direction of Dr. A.B. McDonald, Queen's University, Kingston.

The Neutrino

The neutrino is one of the few fundamental particles of nature. Unlike all other particles it is only influenced by the weak force and for that reason, it is of particular interest to scientists, as a way to study the weak force. The weak force is 10^{13} times weaker than the strong force and so most neutrinos travel unimpeded through matter. For example, for every 10^{10} neutrinos passing through earth only one interacts. Solar neutrinos are created in the fusion processes in the sun's core. Unlike all other forms of energy generated in the sun's core, which take a million years to reach the solar surface, the neutrinos leave the sun immediately so they are the only messenger of current solar core conditions.

The measured deficit in solar neutrino flux could be an indication that the sun's core is colder than surface measurements suggest and, consequently, the sun's lifetime is a billion years less than previously calculated. On the other hand the deficit could be because the solar electron neutrino has changed (or oscillated) into one of the other two types of neutrinos known to exist in nature. These other types cannot be detected by existing experiments but will be by SNO. Such a revelation would have far-reaching implications for physics and cosmology. It would indicate a non-zero neutrino mass which, because there are so many neutrinos in the universe, could be the source of most of the missing mass postulated to exist from other cosmological evidence. It would also narrow the search for grand unification theories of nature's four forces.

The Detector

The SNO detector has a central 1000 tonne region of heavy water contained in an acrylic vessel which is surrounded by 9500 photomultiplier light sensors. The photomultipliers will be mounted on a geodesic structure in a 22 metre diameter by 30 metre high rock cavern filled with ultra pure water.

The cavern is 2000 metres underground where it will be well shielded from cosmic ray backgrounds.

A sketch of the underground excavation is shown in Figure 1. The ramp, used for removing much of the 60,000 tons of rock, will be back filled. The large utility room will house the water circulation, purification and assaying equipment. Also shown are the control room, the lunch and change room and the equipment cleaning area. The change room and cleaning areas

are required to keep the dust levels in the laboratory to a minimum. Dust, containing naturally occurring radioactivity, will be the major source of background to the neutrino signal and so equipment and personnel must be cleaned before entering the observatory. Even trace levels of Ra, Rn and K in the water or on the inner detector components are unacceptable.

A cross section of the detector is shown in Figure 2. The heavy water is contained in a 5 cm thick acrylic sphere supported from the deck by ten pairs of ropes. The sphere is submerged in 7000 tonnes of light water required to shield the heavy water from radioactivity in the surrounding rock. The light water also significantly reduces the forces on the acrylic vessel thereby allowing for a thinner vessel. The photomultiplier array surrounds the vessel and the 2.5 metres of light water between the two reduces the backgrounds in the heavy water from radioactivity in the glass and in the materials of the array.

Very occasionally a neutrino entering the heavy water will interact, producing a high speed electron which emits Cerenkov light as it slows down. This light will be detected by a number of photomultipliers (say 50) which will record the neutrino's time of arrival, its energy and its direction. By putting a small quantity of chlorine in the water its sensitivity to non-electron neutrinos is greatly enhanced, thereby enabling SNO to determine if neutrino oscillation is the explanation for the apparent solar neutrino deficit.

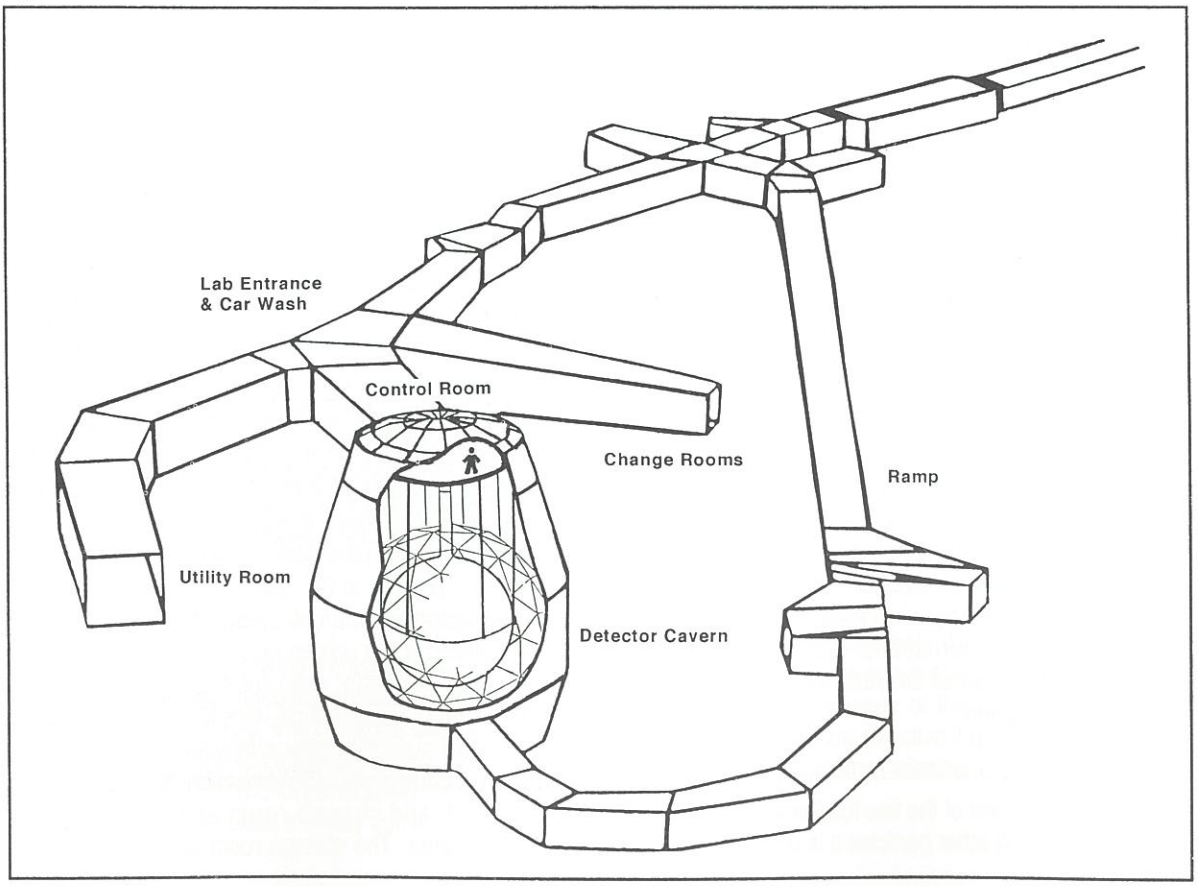
A significant technical challenge is to keep the background due to radioactivity, which also produces high speed electrons, to a minimum. With this in mind, acrylic measured to have thorium and uranium at the level of one part in 10^{13} by weight has been purchased. Vessel fabrication must be controlled so as not to introduce radioactivity at the 10^{12} level. The furnace, which made the glass for the photomultipliers, was constructed of selected materials so as to minimize the glass radioactivity and the water purification system has been designed to produce water containing less than one part in 10^{14} of thorium and uranium. In

The cavern being built in INCO Limited's Creighton Mine for the Sudbury Neutrino Observatory will be as large as a 10-storey building. It will house a huge acrylic bottle which will contain about 1000 tonnes of ultra-pure heavy water loaned from the Canadian inventory.

The $61 million project was begun in 1990 and is scheduled for completion in 1995.

Participating institutions are: University of British Columbia; Carleton University; AECL Research CRL; University of Guelph; Laurentian University; Lawrence Berkeley Laboratories; Los Alamos National Laboratories; Oxford University; University of Pennsylvania; Princeton University; Queen's University.

Figure 1: A sketch of the underground excavation



addition, the thorium and uranium radioactive daughters must be equivalently miniscule and the water system must be able to monitor the levels of some of these isotopes so that the scientists will know the ratio of background events to neutrino induced events.

Status

The cavity has been excavated and lined with shotcrete and a layer of Urylon, a thick polyurethane coating designed to contain the light water. Figure 3 is a photograph looking down at the construction platform on the floor of the cavity from the deck. The two men on the platform provide an appropriate scale. The deck from which the photomultipliers, acrylic vessel and all other detector components will be suspended has been installed. The civil construction in the adjacent rooms is complete and all services have been installed. Later this summer after a replacement construction platform has been installed in the cavity the top part of the photomultiplier structure, with the photomultipliers, will be installed, followed by the acrylic vessel and the bottom half of the geodesic structure. Figure 4 shows the photomultiplier geodesic structure after it was test assembled in California before shipment to Sudbury.

At the same time as the detector components are being installed in the cavity the water plants will be installed and commissioned in the utility room and the electronics and data taking equipment will be installed on the deck and in the control room. The water fill will take place in late 1995 and data taking will begin immediately thereafter. Statistically significant results are expected by late 1996.

Figure 2: A cross section of the detector

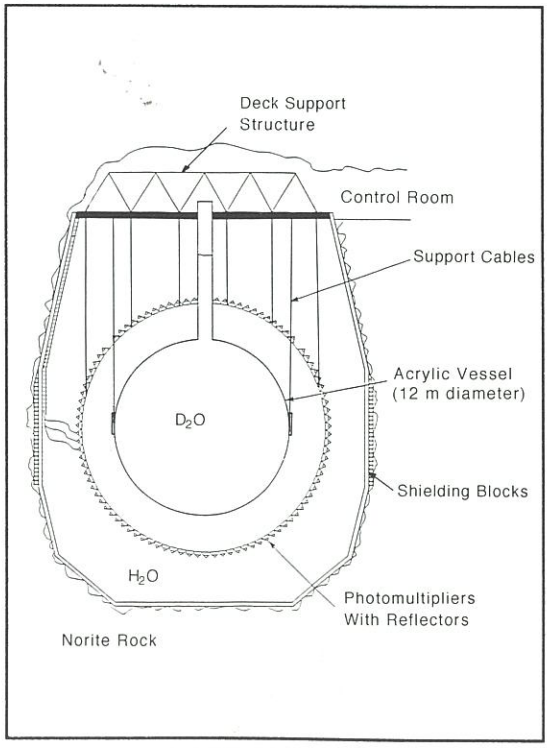


Figure 3: A view of the construction platform at the bottom of the cavity, taken from the deck. Two men are standing on the platform.

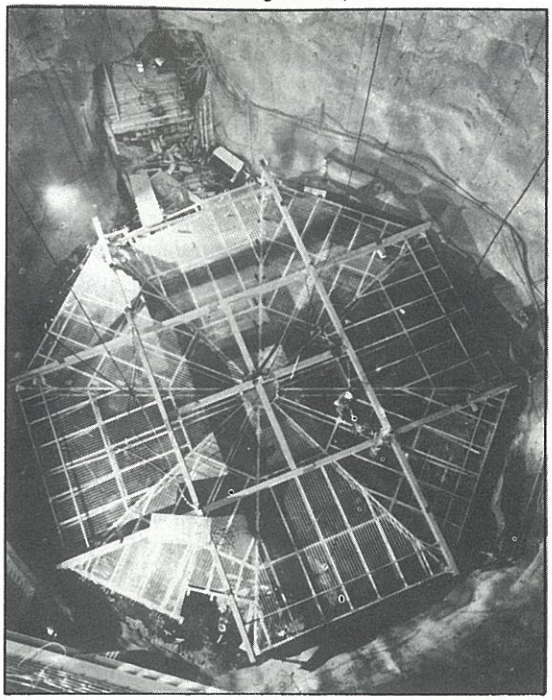
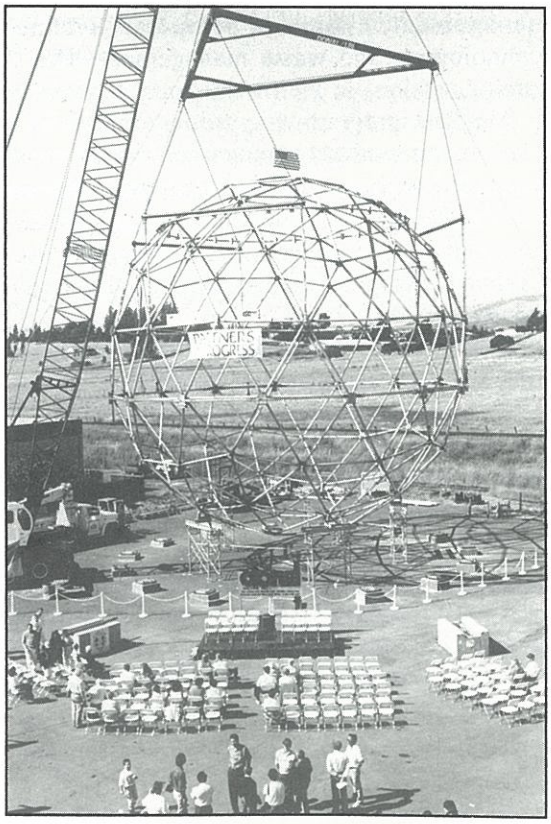


Figure 4: The photomultiplier support structure, dry assembled in California before shipment to Sudbury.



CNA/CNS Annual Conference

Despite the announcement just days earlier by AECL of a staff reduction of 600, despite the on-going death of domestic projects, the mood at the annual joint conferences of the Canadian Nuclear Association and the Canadian Nuclear Society in early June was markedly "upbeat". The over 400 delegates appeared to ignore, or accept, the various ills of the nuclear industry and concentrate on achievements, the future, and, most likely, the inviting ambience of Montreal.

Certainly the organizers helped this positive mood with thorough planning and impeccable execution of all events, not least of which were the excellent meals and the fascinating entertainment. From the opening reception on Sunday, June 5, to the final sessions and technical tours Wednesday afternoon, everything went off on schedule.

Following the format of recent years, Monday morning saw a joint plenary session with a keynote address by Terry Rummery, acting president of AECL (reprinted elsewhere in this issue). This was followed by a session on the economic impact of nuclear power with further reports on the Ernst and Young study (see Vol. 14, No. 4) and presentations from the Quebec and French perspectives.

Monday afternoon the CNA continued with overview sessions on environmental regulations and program updates, while the CNS began its technical program with three parallel sessions. (An overview of the CNS conference is presented elsewhere in this issue.) In addition Daniel Rozon, of Ecole Polytechnique, chaired a special program for Quebec teachers.

Tuesday, the CNA program had sessions on life-cycle management, evolution of nuclear technology, future technologies, and waste management. The CNS ran four parallel sessions in the morning and three in the afternoon.

The CNA program wrapped up Wednesday morning with a session on world economics and energy consumption, and concluded with a much-heralded panel discussion entitled, Nuclear Phobia – Are the Media Taking the Bait?. The panel consisted of six Quebec media representatives, a director of a native development organization, and two from the nuclear industry.

That session was divided into three segments, each beginning with an audio-visual presentation of the results of a newspaper survey of over 147,000 articles in seven major Canadian daily newspapers over the years 1988 to 1994. Of those 1,930 were analyzed for their presentation on: the environment; safety and accidents; economic spinoffs; related to the energy field. On articles related to the environment nuclear energy actually received a more balanced treatment than either oil or hydro. When it came to safety and accidents, oil, coal and nuclear all shared a predominantly negative coverage with nuclear being totally negative. On economic spinoffs all conventional energy received negative reporting although much related to oil and coal was described as "informative".

Wednesday afternoon there were tours available to Gentilly-2 and the Tokamak de Varennes.

The CNS technical program continued all day Wednesday with three parallel sessions in both the morning and afternoon.

At the CNA luncheon, Monday, Guy Saint-Pierre, president of SNC-Lavalin Inc., spoke on the economic benefits of nuclear energy and added his support to Dr. Rummery's call for more private sector involvement in nuclear power marketing. The various CNA awards were presented.

Astronaut Capt. Mike McKay was the guest speaker at the CNS luncheon, Tuesday, and gave a fascinating insight into the physiological aspects of space travel as well as some insightful observations on science and learning. The CNS awards (described in detail elsewhere) were presented.

Tuesday evening may have been the highlight of the conference for many. Following the excellent meal the delegates and their companions were entertained by Natalie Chocquette. A very accomplished singer, Mlle Chocquette entranced her audience with her many styles and climaxed the show by enticing Henri Bordeleau, of Hydro Quebec and overall chairman of the conference, onto the stage to dance with her.

The nuclear industry may be in the doldrums but it is clear that there is still great organizational ability around – especially when it comes to the annual conference. Those involved with the 1995 conference in Saskatoon have a hard act to follow.

Ageing

One of the most interesting, and popular, sessions at the CNA/CNS Annual Conference was on "Plant Life Management". Recognizing that our ageing nuclear plants are not going to be replaced soon and recognizing the pressure to fully return their investment, utilities are now turning their attention to keeping the plants going for their planned 40-year life.

In the U.S.A. where this is also a major concern much of this interest is embraced by the topic "licence renewal" since the USNRC typically gave 40-year licences. Some utilities are already planning at trying to keep their plants operating beyond that licence period.

One positive aspect of this challenge is that it is forcing plant operators, designers, and researchers to work together to anticipate, understand and respond to the many problems presented by degradation, corrosion, and other symptoms of old age.

As our part we intend to devote much of the next issue of the *CNS Bulletin* to this topic and will be looking for input from those already involved in this challenge.

Power and the Future Generation

Dr. T.E. Rummery

Ed. Note: *In his keynote address to the CNA/CNS Annual Conference held in Montreal in early June, Dr. Terry Rummery, at the time acting President and CEO of Atomic Canada Limited, chose to outline the world's need for nuclear energy as well as to comment on the domestic industry. Most of his talk is reproduced below.*

Let's look at the "big picture" first. Electricity has brought prosperity to people who have had the good fortune to live in the developed nations of the world. But there are billions of others living in poverty. What these people desperately need is a reliable source of electricity.

If we look back on the history of world energy use, the burning of fuels such as wood dominated energy utilization until 200 years ago. Since then, we have learned how to use fossil fuels, specifically coal, oil and gas. Only relatively recently, about 100 years ago, did we develop practical applications of electricity.

However, even now, the path to prosperity is not clear for the billions of people who live in the shadow of underdevelopment. In many parts of the world today, wood is still the principal source of heat and light. For them, the picture hasn't changed much in the past 200 years.

The global energy dilemma is simple, but immensely challenging: potentially huge demands in the next century set against concerns about a healthy environment.

Consider:

- The developed nations have a population of about 1.5 billion people. According to the United Nations, that population is projected to increase to approximately 1.9 billion by the middle of the next century.
- The newly developing nations, by contrast, have a population of about 4.2 billion people. By the middle of the next century, that population is projected to rise to approximately 9.5 billion.

To put this another way, by 2050, the population in the developed and affluent nations will increase by about 400 million people. By the same year, the population in the developing and poorer nations will increase by 5.3 billion people.

The people of the developing nations aspire to the comfortable lifestyle that we in the developed world take for granted. And they will seek to attain this lifestyle in the only way that they can – by industrializing their economies as rapidly as possible.

Where is the energy to power all this development, more than doubling the current global requirements, to come from? We can look at a simple, rather telling analysis.

- There is no doubt that the world will continue to rely on fossil fuels for a large proportion of its energy production, perhaps 60%. The burning of coal, oil and gas will expand in Asia, India, Africa and South America. Coal and other fossil fuels make sense to emerging nations because they are readily accessible, use off-the-shelf technology, and the resources to supply them are readily available.
- Developing nations can and will opt for hydro-electrical power to meet some of their needs. But the amount of hydroelectric capacity that remains to be developed is about the same as that which we currently use. So, as the world population doubles, the proportion of energy supplied by hydroelectricity will not increase; it will continue to constitute about 5% of the total world-wide electricity requirements.
- Renewable sources, such as biomass, wood, solar and wind could gain importance, but their proportional contribution will remain small – possibly 10% for biomass, 5% for the other renewables.

Whatever the future mix of energy supply, two points are abundantly clear:

- First, we cannot meet the realistic energy needs of the developing nations for a sustainable standard of living without turning to alternatives such as nuclear power.
- Second, if we don't choose alternatives to a massive increase in the burning of fossil fuels, future generations will bear a heavy environmental burden.

Therefore, the developed nations must collectively do all that they can to foster an orderly growth in electrical supply – based on a mix of energy sources, including nuclear power – so that emerging nations can attain economic self-sufficiency. It is the right thing to do as good neighbours and responsible citizens of this planet.

From Canada's and AECL's perspective, the "right thing" also provides us with significant opportunities to export our nuclear technology abroad. I would like to summarize some of these "opportunities"!

- Turkey represents a good short-term prospect, where in excess of 15,000 megawatts of electrical capacity is expected to be needed by the year 2002.
- Over the same period, Korea projects a need for approximately 28,000 megawatts of additional electricity.
- By 2002, the Philippines will require about an additional 6,000 megawatts of electricity.
- In Indonesia, electricity demand is expected to increase in excess of 13,000 megawatts by 2002.
- In Thailand, 10,000 megawatts more electricity will be required over the same period.
- And in China, a "whopping" 135,000 mega-watts of electricity will need to be added to that nation's generating capacity by 2002.

In total, approximately 220,000 megawatts of increased electrical capacity is estimated to be needed over the next decade in these six countries alone. This need will not be met exclusively by nuclear power, but nuclear will play a significant role in helping to meet these energy demands!

Clearly, there are many opportunities out there, but I must emphasize that the competition will be fierce. And it's not only new reactor sales for which the competition will be intense – we will need to continue to provide the very best services to existing reactors.

Deux études récentes sont extrêmement positives pour EACL et pour l'industrie nucléaire canadienne dans son ensemble. Je suis sûr que vous connaissez déjà l'étude d'Ernst & Young sur «Les retombées économiques de l'industrie nucléaire canadienne.» Il ne fait pas mal, toutefois, de rappeler les importantes retombées pour notre industrie :

- Nuclear energy supplied 15% of Canada's electricity 1992, valued at $3.7 billion.
- The nuclear industry directly employed approximately 30,000 people in Canada in 1992.
- It created a minimum of 10,000 jobs in 1992 in other sectors indirectly dependent on the nuclear industry.
- The nuclear industry also generated federal tax revenues of $700M in 1992.
- And had a trade surplus of $500M in 1991.
- Furthermore, by supplanting coal and oil imports, it is estimated that the nuclear industry provided foreign exchange savings of approximately $1 billion in 1992.

Quite a story. And we have a recent – late 1993 – Angus Reid poll showing continued strong support for the nuclear industry in Canada, support that has weathered the Three Mile Island and Chernobyl accidents. No fewer than 70% of Canadians believe that nuclear power will be important as a source of electricity in the future, and a similar figure supports sale of CANDU reactors to other countries. One might speculate that our successes in Korea and Romania are, in fact, being recognized by Canadians as having a positive impact on the Canadian economy. Indeed, although the domestic market for reactors will remain flat in the near-term, it is these export opportunities, coupled with high-quality services for operating CANDU reactors, that will help secure our investment in the nuclear industry and maintain the nuclear option for Canada's future use.

Now for AECL itself. Most of you are aware that in the latter part of 1993, a Corporate Task Team was examining ways to promote operational efficiencies within AECL. This isn't a new situation. In the 1970s and 1980s, AECL had a workforce close to 10,000, which we reduced to the current 4,300 to match our changing workload and responsibilities. In any event, the flat domestic market, the completion of AECL's portion of some of our overseas projects, and the fiscal restraint measures familiar to us all, would not enable AECL to sustain its current staffing levels.

La haute direction et le Conseil d'administration d'EACL ont fait une évaluation poussée des constations du Groupe de travail. Le résultat de cette évaluation a été l'annonce de la semaine dernière.

The basic AECL structure remains unchanged, with AECL CANDU and AECL Research as the Corporation's two operating divisions. To match our staff numbers to our workload, and to reduce overhead, we are streamlining management positions and support services – for example: human resources, finance, administration, public affairs – by consolidation or amalgamation, to eliminate duplication, operational boundaries and redundant effort. Our staff numbers will be reduced by about 600 positions over the next two years, with the majority occurring this fiscal year. About one-third of the reductions result from matching staff levels with commercial workload. The balance is attributable to the streamlining of management and support functions.

AECL will continue to evolve and change as we position ourselves strategically. This evolution will involve increasing and advancing the CANDU Business, with a continuing close focus on both our domestic and off-shore customers. It will also include development of new products that will position us to pursue one quarter of the emerging world reactor market. The evolution will also entail maintaining a strong research and development program to ensure appropriate support for product development and the advancement of nuclear science in general.

How does all this fit with the industry as a whole? Currently, AECL bears most of the cost of international marketing and sales efforts and assumes most of the risk on big projects. The overall benefit to the industry and to Canada is substantial. I invite greater private sector involvement in the CANDU Business, thereby ensuring an equitable sharing of risks and rewards. We could jointly benefit from a more efficient utilization of our resources in the areas of marketing, financing and project execution.

To gain access to the financing required for CANDU projects, international partnering will be an increasing part of our business development.

On the domestic front, we also need to examine closely complementary and overlapping skills and resources, particularly in the services field. Is there a place for some constructive consolidation of resources that would give more cost-effective, reliable and responsive services to all operating CANDU stations? For the benefit of our industry, we can't shy away from these tough decisions.

Similarly, I'd like to see all CNA members review their level of support for CNA programs which contribute positively to the public's view of the nuclear industry. I ask you the question: Is support for these programs appropriately distributed or is AECL carrying too big a load? I suggest the latter.

Notwithstanding our past achievements, we have only just begun to realize CANDU's potential. It's easy for me to become enthusiastic when I consider our R&D programs on future fuel cycles. I can see that CANDU's natural attributes – high neutron economy, high thermal flux, and on-power fuelling – position CANDU as the technology of the future in terms of fuel cycle flexibility and security of fuel supply. These attributes are beginning to gain increasing attention around the world.

In summary, there are both opportunities and challenges ahead for our industry. In continuing to secure the nuclear technology to provide electricity into the next century for the developing countries, we can be both altruistic and self-serving; altruistic in the sense that we know the technology complements environment, compared with the alternatives; and self-serving in the sense that AECL and the nuclear industry can help re-invigorate and stimulate Canada's economy. But this won't come easily. I look forward to all segments of the industry working together to share equitably the load and the benefits. AECL is willing to take the lead, but we need the support and active involvement of all of you if our industry is to continue to be as successful in the future as it is today.

Technical Program – CNS Annual Conference

Ninety-two papers were presented in the technical program of the 15th annual conference of the Canadian Nuclear Society which was held in Montreal, June 5 - 8, in conjunction with the 34th annual conference of the Canadian Nuclear Association.

The papers were divided into nine categories and presented over two and a half days in typically three parallel sessions (except for Tuesday morning when there were four sessions).

The categories were: thermalhydraulics; fuel channel; operations; reactor physics; fuel; technology; safety; training; waste management.

To give those readers who were unable to attend the conference some flavour of the nature and quality of the various papers, following are summaries of nine papers, one from each of the categories, selected rather arbitrarily and subjectively.

Proceedings of the conference, with full papers, are available in a two-volume set for $100 from the CNS office.

Thermalhydraulics / Thermalhydraulique

A CANDU Multiple-Channel Thermosyphoning Flow Stability Model

P. Gulshani, AECL-CANDU
H. Huynh, Hydro Quebec
A. Galia, New Brunswick Power

An algebraic linear model (dubbed MMOSS for Model Multiple-channel OScillationS) has been developed to explain and predict pass-to-pass out-of-phase oscillatory behaviour in a CANDU-type multiple-channel figure-of-eight loop under two-phase thermosyphoning conditions. Presently, a simulation model of CANDU with a large (about 100) number of channels is impractical due to the resulting slow simulation speed and large memory requirement.

Two-phase thermosyphoning conditions are predicted by thermohydraulic codes for some postulated accident scenarios in CANDU. Low pressure two-phase thermosyphoning experiments in the multiple-channel RD-14M facility have indicated that (pass-to-pass out-of-phase) oscillations in the loop conditions caused the flow in some of the heated channels to undergo sustained reversal in direction. This channel flow reversal had significant effects on the channel and loop conditions. It is, therefore, important to understand the nature of the oscillations and be able to predict the conditions for the onset of the oscillations or for stable flow. For stable flow conditions and at low pressure, the coolant in the channels continues to flow in the forward direction.

MMOSS was developed for a figure-of-eight system any number of channels. The system characteristic equation was derived from a linearization of the conservation equations for mass, momentum, and energy. MMOSS is a simple generalization of a previous model for a single-channel system. In this paper, the MMOSS characteristic equation is solved for a system of N identical channels. This simplification provides valuable physical insight and some reasonably accurate results. Furthermore, the simplification is not unrealistic because, in a multiple-channel system, a group or groups of channels are nearly similar.

This model predicts N modes of pass-to-pass out-of-phase oscillations. In one of the modes, the flow oscillations in all the channels in a given pass have the same amplitude and phase. The amplitude of the oscillations decreases with the square root of the number of channels. Therefore, a system with a large number of channels (such as CANDU) may be expected to be more stable than a system with a small number of channels (such as RD-14M). Therefore, at low pressure, a system with a large number of channels is less likely to exhibit channel flow reversal. In each of the other N–1 modes, the flow is steady in some of the channels. In the other channels except one, the flow oscillations have the same amplitude and phase. In the one channel, the flow oscillation is out-of-phase with those in the other channels and its amplitude equals the sum of those in the other channels. Therefore, in these N–1 modes, the thermosyphoning (*i.e.*, total) flow is steady. Consequently, in these modes and at low pressure, the coolant in the channels continues to flow in the forward direction.

From the MMOSS characteristic function for RD-14M under two-phase thermosyphoning conditions, a flow stability map is generated as a function of loop integrated void, secondary side pressure, and channel power. MMOSS predicts that the flow is stable above about 4 MPa secondary side pressure. At a given pressure below this pressure, the flow is unstable over a range of the void. This range is larger the lower the pressure. These predictions agree reasonably well with the results of the RD-14M experiments.

Fuel Channel / Canaux du combustible

Development and Validation of Analytical Method of Fuel Coolability in Pressure Tube Rupture Event

T. Hasegawa, K. Terunuma, Y. Morishita, S. Sugawara
Power Reactor and Nuclear Fuel Development Corporation, Japan

Coolability tests of fuel cluster were carried out using a full-scale test facility, under a hypothetical pressure tube rupture event in which it was supposed that the coaxial Calandria tube does not rupture and serves as a pressure boundary. An analytical method was developed for evaluation of fuel cluster coolability in a pressure tube rupture event using the subchannel analysis code COBRA-ATR, modified for this study, and the code was validated through analysis of the full-scale tests. The result of this analysis indicates that the modified COBRA-ATR code can be applied to predict the peak fuel cladding temperature in a pressure tube rupture event.

Operation / Opération

On-Line Reactor Building Integrity Testing at Gentilly 2 (Summary of Results 1987-1994)

N. Collins, P.J. Lafrenière, Hydro-Québec

In 1987, Hydro-Québec embarked on an ambitious development program to provide the Gentilly 2 nuclear power station with an effective and practical Reactor Building Integrity Test.

In October 1992, Hydro-Québec performed the inaugural low pressure 3 kPa(g) nominal Containment Integrity Test (CIT) at 100% F.P. The test was conclusive and the CIT System was declared In-Service for containment integrity verification on-line. Three subsequent CIT System tests performed in 1993 have demonstrated the expected leak rate results and good system reliability. The outstanding feature of the CIT system is its demonstrated accuracy of better than 5% of the measured leak rate.

The CIT System was developed with the primary goal of demonstrating "overall" containment availability. Specifically, it was purported to detect a leak or hole in the "bottled-up" Reactor Building greater in magnitude than an equivalent pipe of 25 mm diameter.

The Gentilly 2 CIT employs an innovative approach based on the Temperature Compensation Method (TCM) using a reference volume. The reference volume is composed of an extensive tubular network of several different diameters. This eliminates the need to track numerous temperature points. A second network includes numerous air sampling points thereby enabling the measurement of minute pressure variations of the Reactor Building independent of the spatial and temporal humidity behaviour.

This configuration has been demonstrated at both high and low test pressure. The Gentilly 2 design allows the CIT to be performed at a nomimal 3 kPa(g) test pressure during a (12) hour period (28 hours total with alignment time) with the reactor at full power. The Reactor Building Pressure Test by comparison, is typically performed at high pressure (124 kPa(g)) in a (6) day critical path window (8 days total with alignment time) during an annual outage.

The high precision of the Gentilly 2 CIT and the stable Reactor Building leak characteristic permit extrapolation of the CIT leak rate result to an equivalent Reactor Building Pressure Test leak rate. Continued demonstration of the precision and feasibility of this extrapolation should constitute sufficient grounds for the reduction of the Reactor Building Pressure Test frequency. However several years of CIT System operation are required in order to confirm the long term stability of the Reactor Building characteristic.

This paper provides a general review and overall assessment of the Gentilly 2 CIT System to the end of May 1994. In addition the Safety and Licensing implications are examined in light of the current regulatory position.

In conclusion, the actual performance of the CIT System allows Hydro-Québec to claim a significant advance in Reactor Safety.

1. Hydro-Québec is able to identify a level 3 impairment of containment (>5% Vol/day) using the on-line CIT.
2. Hydro-Québec is able to monitor the degradation of containment between Reactor Building Pressure Tests.

Reactor Physics / Physique du réacteur

Reactor Noise Measurements in the CANDU Units of Ontario Hydro

Oszvald Glöckler, Ontario Hydro Nuclear

Reactor noise analysis techniques are being applied in Ontario Hydro's CANDU nuclear generating stations to monitor the dynamic characteristics of critical plant components, processes and their instrumentation. A comprehensive analysis of stationary signal fluctuations (noise) of the standard instrumentation at Pickering-B, Bruce-B and Darlington units has been carried out in the past two years. In these measurements the feasibility of applying noise analysis techniques to actual operating data has been demonstrated. The results indicated that the detection and characterization of instrument and process failures, and validation of process signals and instrument functionality can be based on the existence of certain statistical features of the measured reactor noise signals.

Fuel / Combustible

Analysis of a Defect Excursion at the Point Lepreau Nuclear Generating Station

B.J. Lewis, A.C. Harnden-Gillis, C.E.L. Hunt
Royal Military College of Canada
R.A. Gibb, T.M. Whynot
New Brunswick Power

A fission product release model has been applied to the analysis of increased activity levels in the primary transport system at the Point Lepreau Nuclear Generating Station following a defect excursion. A comparison has been made between the predicted and measured coolant activity levels of ^{88}Kr, ^{133}Xe, and ^{135}Xe, as a function of time, resulting from a known number of defective fuel bundles (based on post-irradiation examination) that had been introduced into the core during refuelling. The model has also been used in a reverse procedure to predict number of defective fuel elements present in-core based on an analysis of the coolant activity during steady-state conditions.

Technology / Technologie

Light Duty Utility Remote Manipulator for Underground Storage Tank Inspection and Characterization

Peter W. Kruse, Geoff Cunliffe
Spar Aerospace Limited
Betty A. Carteret
Westinghouse Hanford Company

The Light Duty Utility Arm (LDUA) is a remote manipulator which is being designed and fabricated to perform surveillance and characterization activities in support of the

remediation of underground storage tanks at the Hanford site as well as other U.S. Department of Energy (DOE) sites. The LDUA is a highly dexterous manipulator which utilizes an advanced control system to safely and reliably deploy a series of sensors to characterize underground storage tanks. The electrical components of the in tank system are radiation hardened and the mechanical components are designed to operate in the corrosive environment which exists in the tanks. The use of this system will allow the DOE to sample and characterize the waste material in the tanks prior to the initiation of waste retrieval operations.

Safety / Sûreté

CANDU Passive Heat Rejection Using the Moderator

W.P. Baek
Korea Advanced Institute of Science & Technology
N.J. Spinks, AECL Research

Passive moderator cooling systems (PMCS's) are being developed to provide an emergency heat rejection path from the CANDU reactor core to the air outside containment during the unlikely event of a loss-of-coolant accident (LOCA) that coincides with the failure of emergency coolant injection. PMCS's incorporate single- or two-phase natural circulation of heavy water, single-phase natural circulation of light water, and natural-convection air heat transfer, connected in series. Analysis confirms PMCS's can reject the moderator heat for an unlimted time following an accident. The PMCS, combined with other advanced heat rejection concepts, appears to lower the core melt frequency by at least an order of magnitude with little impact on economics. Further work is being performed to improve the design and improve the economics. A scaled test for the flashing-driven two-phase natural circulation within the heavy-water loop is planned to verify the overall concept and to assess the computer codes used in the analysis.

Formation / Training

L'évolution du simulateur de Gentilly-2 depuis sa mise en service

Léo Danylo, Hydro-Québec

Le simulateur pleine échelle de Gentilly-2 est utilisé depuis janvier 1989 pour :

- former le personnel autorisé ;
- effectuer des examens de la Commission de Contrôle de l'Énergie Atomique (CCEA) ;
- effectuer le recyclage des équipes de quart ;
- développer les procédures d'exploitation sur incident (PEI) ;
- recycler les équipes de quart de la centrale d'Embalse (Argentine) et développer leurs PEI ;
- vérifier les modifications faites aux ordinateurs de commande de la centrale de Gentilly-2.

Pendant toutes ces années, le simulateur a été modifié pour :

- refléter les changements faits à la centrale ;
- répondre à de nouveaux besoins de formation (non prévu initialement) ;
- corriger les déficiences des modèles de simulation.

Ce papier présente, en premier, un bref historique des activités de formation donnée au simulateur de Gentilly-2. L'utilisation du simulateur par les différents intervenants est ensuite expliquée.

La caractérisation des différentes déficiences du simulateur trouvées depuis 1989 est ensuite présentée. Cette caractérisation montre les principales causes des déficiences. La plus importante de ces causes est l'ajout de variables contrôlées par l'instructeur ainsi que la correction des modèles pour que le simulateur représente bien les systèmes fonctionnant avec ces variables.

Les modifications importantes faites au simulateur (matériel et logiciels) sont ensuite décrites.

La modification majeure a été induite par l'intégration de la centrale de Bécancour au poste de sectionnement de Gentilly-2. Deux (2) panneaux de la salle de commande ont été refaits. Les modèles des systèmes électriques ont été reprogrammés.

Finalement, nous présentons les défis que nous aurons à affronter dans l'avenir, c'est-à-dire le vieillissement du matériel, l'assurance-qualité des programmes de simulation et le temps d'utilisation du simulateur.

Waste Management / Gestion de combustible usé

Dry Storage of Irradiated CANDU Fuel at Pickering NGS

R.N. Sumar, S. Jonjev, Ontario Hydro

Ontario Hydro generates about 86 million MWe-h/ year from its 20 nuclear CANDU reactors. The combination of a large generating capacity and relatively low fuel burn-up means that Ontario Hydro must manage very large volume of its used fuel. Irradiated fuel bays at Pickering NGS will be full by mid 1995. Additional storage capacity will be required by this date for the station to continue operation.

Several long term storage options to supplement existing on-site facilities were studied. The dry storage system, based on the modular storage container, as an option, was found to be economical and operationally simple.

The dry storage facility at Pickering NGS is planned to provide additional on-site storage capacity for fuel generated from 1994 to the end of the station's operating life (year 2025).

This paper describes the design and operation of the Dry Storage System at Ontario Hydro's Pickering Nuclear Power Generating Station.

The facility is planned as a two-phased project. Phase I will provide a storage space for 700 dry storage containers (268,800 fuel bundles) or about 12 years of station's operation. Phase II will have the capacity for additional 800 containers (307,200 fuel bundles) and will provide storage until station decommissioning in 2025.

Seventy containers will be required annually to meet storage requirements of the station's operation at 100% capacity factor. Staff of six persons will be required to operate the facility.

Normal operation includes activities such as receiving and commissioning new containers, loading them with 4 modules of used fuel in the bays, draining and drying the cavity, decontaminating the container surface and lid welding. Helium leak test is performed before the container is placed in the storage.

IAEA Meetings

The International Atomic Energy Agency (IAEA) is holding two meetings this fall that may be of interest to readers of the *CNS Bulletin*.

From September 5 to 8, the IAEA is organizing an **International Conference on the Nuclear Power Option**, forty years after the start of the first civil nuclear power plant. The conference, which will be held in Vienna, is intended to provide an extensive overview of present and future plans for global electricity production using nuclear power. A second part of the conference will review experience gained over the past 40 years with the 430 existing nuclear power plants.

In cooperation with the French Institute for Protection and Nuclear Safety the IAEA is presenting an **International Conference on Radiation and Society** to be held in the new conference facility at the Louvre, Paris. The objective is to review knowledge of radiation risk through case studies of topics such as cancer and leukaemia clusters, Chernobyl health effects, and radioactive waste disposal: and to examine aspects of the interplay between expert advice, public and media perceptions, and the decision-making process.

Information on these conferences can be obtained from the IAEA, in Vienna, Austria, FAX No. 43-1-234564.

Nuclear Safety Convention Formalized

At a conference convened in Vienna in June delegates from 84 countries and four international agencies adopted a **Convention on Nuclear Safety**. The **Convention** will come into effect after 22 countries have ratified, accepted or approved it, which must include 17 countries having at least one nuclear power plant.

Although slightly modified by this diplomatic conference this **Convention** is essentially that which a group of almost 100 experts under the chairmanship of **Zigmund Domaratzki** of the Atomic Energy Control Board have spent the past two years drafting.

The scope of the **Convention** is limited to nuclear power plants. It puts the onus on signatory states to ensure safety through an effective legislative and regulatory framework. Review meetings will be held at least every three years at which each signatory state must submit a comprehensive report on measures taken to implement the obligations of the **Convention**.

FEARO Funding for Waste Concept Review

The Federal Environmental Assessment Review Office (FEARO) has announced that up to $597,500. will be available to assist individuals and groups to review the Environmental Impact Statement for the deep geologic disposal concept for high level radioactive waste and to prepare and participate in the upcoming public hearings by the Environmental Assessment Panel. Of that amount up to $225,000. will be allocated specifically for technical and scientific reviews of the EIS and supporting documents.

Applications for funding must be received no later than 19 September 1994.

For further information contact FEARO, FAX 819-994-1469.

Workshop on Safety of Soviet-Design NPPs

A workshop will be held in Washington, D.C. 11-13 November, immediately prior to the ANS Winter Meeting, on the safety of Soviet-designed nuclear power plants.

This is the second such workshop and is sponsored by the ANS Nuclear Reactor Safety division, the U.S. Department of Energy, USNRC, and the IAEA. The focus will be on progress in enhancing the safety of the subject plants and challenges to further safety improvements.

For information contact Dr. Robert Bari, Brookhaven National Laboratory, Upton, New York, U.S.A., Tel. 516-282-2629, FAX 516-282-5266.

CALL FOR PAPERS

The organizers of the 1995 **Annual Conference of the Canadian Nuclear Society**, which will be held in Saskatoon, 4-7 June 1995, have issued a Call for Papers.

Papers are invited on technical developments in all subjects related to applications of nuclear technology. Papers on advances in the state of the art and on future developments are encouraged.

To be considered, summaries of 750 to 1200 words must be submitted before **16 December 1994.** Notification of acceptance will be provided by 28 February 1995.

Summaries should be submitted to:

Dr. A. L. Wight
Canadian Nuclear Society
Saskatchewan Branch
P.O. Box 932
Saskatoon, Saskatchewan S7K 3M4

For information contact Al Wight at:

Tel. 306-665-4841
FAX 306-975-6159

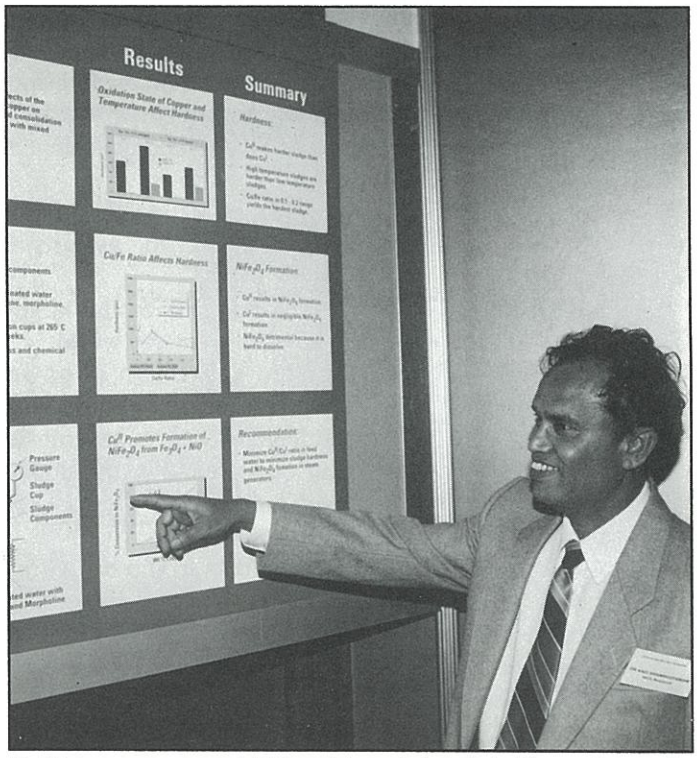
2nd International Steam Generator and Heat Exchanger Conference

Ed. Note: *Despite following just one week after the CNA/CNS Annual Conference, the Second International Steam Generator and Heat Exchanger Conference in Toronto in mid-June drew over 200 participants which pleased the organizers but over-taxed the facilities. This response and the active discussion which took place are clear testimony of the importance steam generators for the future of nuclear power plants and the concern held over their performance. The conference was sponsored by the CNS with co-sponsorship of the CANDU Owners Group.*

The following report was prepared by Ed Price, the new president of the CNS, together with Derek Lister, conference chairman, and Victor Murphy, conference secretary. The accompanying photographs were taken by Victor's daughter.

The second International Steam Generator and Heat Exchanger conference was very well attended, exceeding the expectations of the organizers, with 200 delegates from eight countries.

The quality of the papers was very high and covered a broad range of steam generator technology which proved an attraction to many. Over the three days (June 13 – 15, 1994) there were sessions on: Operation; Inspection and Maintenance; Cleaning; Thermal Hydraulics, Vibration and Fretting; and Materials and Chemistry. In addition there was a poster session, held in conjunction with a reception, where the authors were subjected to more scrutiny than the verbal presenters.



K. Shamsuzzaman of CRL points out details in his poster on the role of copper in consolidation of sludge.

The three major issues addressed were: (1) the impact of deposit fouling on efficiency, impurity concentration and corrosion, and, how to remove deposits; (2) improvements in thermalhydraulic modelling and experiments to understand flow blockage; and (3) improvements in inspection techniques and repair options.

The opening paper by Stipan and Tapping reported on the COG sponsored survey of worldwide steam generator operating performance. *(See abridged version in this issue.)* Lillian Stipan, who presented the paper, showed graphical analyses to show that there is a continuing increase in tube plugging despite increasingly stringent water chemistry specifications. Steam generators of all vendors have been subject to tube degradation requiring plugging. Boric acid additions do not appear to be effective inter-granular stress corrosion cracking (IGA/SCC). Slama, of Framatome, outlined the evolutionary design of the N–4 steam generators which has used computer codes for thermal hydraulics and vibrations. The problems at the Bruce 'A' station were outlined by Roy who reviewed measures being taken to reduce deterioration by intergranular attack produced by excessive corrosion of the carbon steel supports. Carmina Maruska described life-cycle management practices at Bruce 'B' to avoid similar problems. The final paper of the opening session was on the Canadian regulatory approach to steam generator safety. *(See elsewhere in this issue.)*

The session on Inspection and Maintenance had reports on interesting developments in inspection and repair. Improved eddy current probes have been developed by AECL's Chalk River Laboratories for circumferential cracks in tubing. Matsumoto reported on a potentially powerful neural network program for rapid analysis of eddy current signal patterns. Elder of Westinghouse described laser weld sleeve repair techniques for I-600 alloy tubes.

In the Cleaning session a paper by Denuit and Chauveau of EdF/Savac outlined a cleaning procedure for the N–4 steam generators which requires a large number of wall penetrations for the insertion of rail mounted miniaturized lancing heads. Evans of Ontario Hydro described a facility for treating the wastes from cleaning.

The two sessions on Thermalhydraulics, Vibration and Fretting began with a paper by Campagna on modelling to validate the THIRST code against the CLOTAIRE experiments. Turner described modelling of magnetite particle deposition. The audience was intrigued with Helena Rummens' descriptions of relatively simple experiments that provided insight into the deposition process at support plates and indicated that formed bar supports were better than lattice bars and broach plates.

The second session concentrated primarily on flow induced vibration and fretting. Development of the THYC 3D code was described by Ting of EdF. Testing of tube arrays

in freon was the subject of papers by Saito of Mitsubishi and Pettigrew of AECL-CRL.

In the Materials and Chemistry session, papers by Japanese researchers reviewed tests on the effect of impurity ions on IGA/SCC and described a 5 year program to examine the causes of IGA on I-600 and I-690 alloys. Villegas reported on the corrosion of I-800, in particular its anodic behaviour and passivity breakdown. Lead contamination is an important factor (as evidenced in Bruce 'A' unit 2). A paper by Rocher and others from EdF reviewed potential sources and procedures to prevent its entry.

The Poster session produced some excellent displays, including procedures to test joint integrity; sludge consolidation; amine treatment; testing of separation equipment.

Overall it was a very successful conference. With the rapid developments in this field the interval until the third conference should be less than the four years between the first and second.

Steam Generators and Ontario Hydro

Don Anderson

Ed. Note: *Don Anderson, General Manager of Ontario Hydro Nuclear, gave the welcoming address to the Second International Steam Generator and Heat Exchanger Conference held in Toronto in mid-June. Following is most of his prepared talk.*

There's no better measure of the significance and interest in steam generators and heat exchangers than the fact that the CNS has had to turn people away from this conference. Speaking on behalf of Ontario Hydro Nuclear, I can tell you that the performance of our steam generators has become an over-riding concern, as it is for many other utilities around the world.

Four years ago, our former president gave the welcoming address at your inaugural conference, and he spoke about some of the challenges facing Canada's nuclear industry and the reasons we were planning to build more nuclear units.

Looking back, with all that's happened at Ontario Hydro since then, those four years seem more like four decades.

We are on our third chairman since 1990. We've undergone a major restructuring and re-engineering, slashed capital spending to the bone, and shed more than 10,000 full time and contract staff.

In 1990, Hydro had just released a multi-volume, long-term plan for meeting Ontario's future electricity needs. That plan called for the construction of up to 10 new nuclear units, as well as new hydro-electric plants and even gas-fired units if demand grew faster than expected.

But instead of scrambling to meet rapid demand growth, we are now in our fifth straight year of flat or declining sales. We haven't broken ground on any of those proposed units, and the long-term plan has been safely stored away to collect dust.

Instead of building new facilities to meet rising demand, we've been mothballing and shutting down some of our existing generating units because of surplus capacity.

While the vast majority of the units affected have been from our fossil stations, we are planning – as of September 1995 – to shut down our first nuclear unit: Bruce Unit 2. It is a special case, and I'll return to it in a few minutes.

First, I'd like to remind you that when Bob Franklin spoke four years ago, he made no reference to Hydro's steam generator problems – for the simple reason that we didn't have any at the time.

How things have changed.

Since then, we've discovered a whole litany of corrosion and pitting problems in our boiler tubes, and even some leaks. We've undertaken major boiler cleaning programs on four of our units, and we are planning more over the next several years.

Even the 20-year-old Pickering 'A' units, which have been problem-free and the envy of similarly-aged stations around the world, are now showing the effects of time and corrosion.

There's an old Spanish proverb that says the bull looks very different when you climb down from the viewing stand and get into the ring.

We at Ontario Hydro certainly have a different perspective on steam generators now that we are experiencing the same problems that have plagued other nuclear utilities.

Admittedly, some of the problems are of our own making. In retrospect, we didn't pay as much attention to maintenance as we should have over the years. We underestimated the resources necessary to support the operation and maintenance of 20 large nuclear units.

Part of the problem was that much of our focus was devoted to building new units in step with the ever-rising demand for energy.

For almost three decades we've had one of the largest nuclear expansion programs of any utility in the world.

With the abrupt and prolonged slowdown in power demand growth in Ontario – combined with a moratorium on new nuclear stations imposed by the new Ontario government in 1990 – we are now focusing on optimizing the performance of our existing units over their service lives, rather than building or even planning new units.

While past neglect has caused our units to slip badly from their world-leading performance levels, I am optimistic that we are now beginning to turn things around.

First of all, the recent corporate restructuring has enabled us to better focus on the challenge ahead. It brought all the groups and functions in the Corporation involved in the nuclear side of the business one united organization – Ontario Hydro Nuclear. And it allowed us to combine engineering and operations staff at our stations to work on cross-functional, problem solving teams.

At the same time, we've introduced a continuous improvement program – known as the business improvement process (BIP) – to unleash the energy and know-how of all 9,300 employees in OHN.

Already, there are more than 100 BIP teams in action, looking at ways to improve everything from employee radiation dosage to chemistry control.

I have great expectations for BIP, and can't emphasize its importance strongly enough given the limited resources we face in today's slow-growth electricity market. Small, rapid, incremental improvements – driven by people at the workface – can go a long way in helping us return to the world-leading performance levels Ontario Hydro enjoyed in the past.

Finally, with some of our units now in their second generation, we are paying a lot more attention to ensuring the units last through their planned 40-year lives.

Life management is a major, if recent, concern of Ontario Hydro Nuclear. We have 20 large nuclear units at various stages in their life cycles. The Pickering 'A' and Bruce 'A' units are middle-aged plants, while the Pickering 'B' and Bruce 'B' units are still relatively young. Darlington, as you know, is our newest station.

Our oldest unit, Pickering Unit 2, is presently scheduled to come to the end of its planned 40-year life span in the year 2011.

The challenge is to ensure those units reach a ripe old age safely, reliably, and competitively – and not have to replace any steam generators in the 40-year station lifetime (except for Bruce 2).

We plan to achieve that by managing the life cycles of our units at three broad levels.

1. **Manage the investment** – by that I mean there must be a clear strategic plan for each unit, that includes a revenue stream and year-by-year capital stream. That plan should guide appropriate investment decisions.

Laura Obrutsky of CRL presents a paper on Eddy Current Probes for detecting circumferential cracks in boiler tubes. Co-chairmen Stu Groom of NB Power and M. Behavesh of EPRI look on.

2. **Learn from experience** – here we are talking about the "plan, do, check, act" model of maintenance inspection to ensure long-term safety and reliability of the units overall. Experience tells us what potential problems to look for, and how we can avoid or correct them.
3. **Avoid surprises** – the Holiday Inn approach of no surprises has value when it comes to high cost components – such as steam generators – whose untimely failure could mean high repair or replacement costs. The cost could be such that it results in a premature shutdown – as we've seen with Bruce Unit 2.

Life cycle management represents a new frontier for OHN and many other utilities. While we've always recognized the importance of good maintenance, only recently have we begun developing formal, disciplined programs to ensure the longevity of our units.

Our first attempts at doing the analysis and developing strategic plan for any of our units was in the Bruce 'A' economic assessment, which was conducted back in September 1992, and the capital and capacity study, which ultimately led to the decision to shut down and lay-up Bruce Unit 2.

In both cases, detailed economic assessments were done, though only in the latter was the information used to develop an actual plan.

That plan looked at the cost of rehabilitating the boilers and retubing Unit 2 in the context of Ontario's predicted electricity surplus over the next decade and determined that the investment could not be justified.

The decision to shut the unit down in September 1995 reflected the advanced deterioration of the boiler tubes, which is the result of a lead blanket being left in one of the boilers during maintenance back in 1986.

The blanket interfered with chemical control in the boilers and accelerated the resulting corrosion.

Developing strategic plans for the other Bruce 'A' units will be key in making capital investment decisions when those units come due for retubing. Again, this plan will have to consider expected energy demand and balance the retube and rehabilitation costs with other supply options.

Because of their enormous repair and replacement costs, steam generators are going to be a major focus in our life cycle management programs.

Other than Bruce Unit 2, our boilers are in relatively good shape, at least compared to those of many other utilities. We still face significant cleaning and repair costs, but at the moment, none of the boilers appear to threaten the lives of any of our units.

Moreover, we've developed effective cleaning and repair techniques – which will be explained in detail at some of the technical presentations.

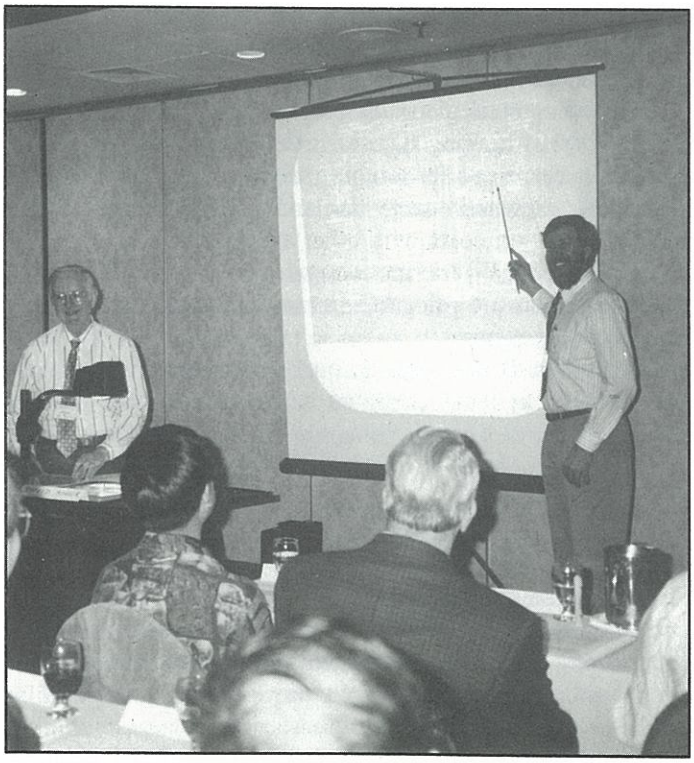
I would just add to that by saying that we are hoping that better boiler chemistry control will mitigate the frequency of additional cleans, and help our newer units avoid similar corrosion problems down the road.

I know at the new Darlington plant, the staff are fanatical about boiler chemistry. When you are dealing with an investment on the scale of Darlington, a little fanaticism is welcome.

Potpourri

Natalie Chocquette entertained at the CNA/CNS banquet during the Annual Conference in Montreal in June 1994.

Conference chairman Prof. Derek Lister presents Dr. Suart Odar of Siemens the prize for best poster presentation at the 2nd International Steam Generator and Heat Exchanger Conference.



David Barber (L) and John VanBerlo point out features in the flow chart of a CANDU System to attendees at the "Introduction to CANDU Chemistry Course" presented by the CNS in March 1994.

Ed Zaltsgendler of Ontario Hydro answers questions following his presentation on fouling trends in Bruce 'B' Steam Generators at the 2nd International Steam Generator and Heat Exchanger Conference.

Steam Generator Operating Experience

L.M. Stipan, AECL CANDU
and R.L. Tapping, AECL Research

Ed. Note: *The lead-off paper at the 2nd International Steam Generator and Heat Exchanger Conference held in Toronto in June, 1994, a report on the extensive survey conducted by AECL CANDU of steam generator performance, was presented by Lillian Stipan of AECL CANDU. Following is an abridged (due to space limitations) version of that paper. The full version, with more tables and figures, can be obtained from the authors and will be in the proceedings of the conference which will be available from the CNS later this year.*

Introduction

Since 1971 AECL has surveyed world-wide steam generator (SG) operating experience. Most recently the survey has been co-funded by the CANDU Owners Group (COG); prior to that the Electric Power Research Institute (EPRI) co-funded the survey for two years. Although the first surveys concentrated on SG tube failures, and these are still an important part of the survey, the current surveys include a wide range of information on condensers, cooling water type, tube repair, NDE methods, SG replacement, sludge characteristics, operating chemistry, etc., and attempts to collect information relevant to both SG operators and designers. The survey information can be used to track trends in, for instance, SG tube failure rate, and the effectiveness of remedial and repair methods, or SG replacement strategies. These trends and their related causes can be used to improve designs and to improve operating procedures for existing and future designs.

In this paper several examples of the information available from the survey will be presented in order to illustrate the versatility of this database.

2. Trends in SG Tube Plugging

SG tubes are removed from service, or plugged, when they leak or display inspection characteristics interpretable as flaws which exceed allowable sizes. The inspection data can often be interpreted/correlated to specific degradation mechanisms, and trends in tube plugging attributable to specific mechanisms can be presented as a function of time, as illustrated in Figure 1. This type of plot has become a popular means of charting trends in degradation mechanisms, and it is important to note the change in cause of SG tube plugging from the early 70s (wastage) until now (OD stress corrosion cracking / intergranular attack (SCC/IGA). Plots such as those illustrated by Figure 1 suggest that the annual incidence of tube plugging, which has been in the range 0.1 to 0.4% of those in service, is the result of an increasing family of degradation mechanisms.

Figure 1 indicates a significant increase in the percentage of tubes plugged because of secondary side SCC and/or IGA in 1991 compared to the previous few years. In reality, much of the tube plugging related to failure causes associated with specific fabrication practices for Alloy 600 tubing, and to the fact that many of the degradation mechanisms now causing problems have a long incubation time. It is important to note that, in effect, Figure 1 incorporates the sensitivity of specific designs to degradation (drilled support plates and denting), and the possible deleterious effects of specific operating chemistries (phosphate wastage).

3. Cumulative SG Tube Performance

A log-log plot of the tube failure rate (cumulative tubes plugged per 100 tubes in service) versus effective full-power days (EFPD) is given in Figure 2. The data are presented so that the tube performance between SGs before replacement and tube performance after those SGs were replaced, is apparent. To date, much better tube performance has been obtained with replacement steam generators. The CANDU stations are also identified in Figure 2, and this shows the variability in performance of the various CANDU steam generators. Most of the CANDU units have steam generator performance below the F=0.01 line, which indicates very good performance in terms of tube plugging to date.

SGs where F is greater than 1, will likely require SG replacement or large-scale repair, and most of the SGs above the F=1 line contained low temperature mill-annealed Alloy 600 tubing. SGs with Alloy 800 tubing are below the F=0.1 line. With the longest in-service life of any SG tube being about 20 years, it is not yet possible to use the information such as in Figure 2 to extrapolate SG condition at full design life, although extrapolation of the plugging rate after 20 years may be a reasonable predictor of service life. SGs below the F=0.01 line, and possibly the F=0.1 line also, have survived most of the known degradation crises to date, and, assuming good operation from now on, should provide continued good service.

4. Location of Defects

Table 1 shows the location of defects in 1991. The majority of steam generators have defects in the tube support plate area, but steam generators with defects in the sludge pile, within the tubesheet and in the U-bend area are also common. In the earlier surveys there were more defects located in the tubesheet and sludge pile, but the trend now is to an increasing incidence of pluggable indications in the tube support intersections. There are now more defects on the secondary side than on the primary side, largely because some remedial methods have been found to be effective in combatting primary side SCC (PWSCC).

Secondary side degradation appears to be closely related to chemistry and chemistry control. Of the 215 reactors in the survey in 1991, approximately 175 were using *all volatile treatment* (AVT); fourteen of those reactors switched to AVT from phosphate in 1991, following concerns for

phosphate wastage. By the end of 1992, 37 stations were using, or had at some point used, boric acid addition, to combat either denting or secondary side intergranular attack (IGA). Of those stations which have been using boric acid addition for more than five years (19 in total), 74% have experienced an increase in the number of failed tubes and are still observing secondary side SCC/IGA.

Representative stations were selected to determine what, if any, benefit boric acid addition has had on SG tube failures. The data show that some stations have had a decrease in SCC/IGA following boric acid addition, but others have seen no change or an increase in tube cracking. While it should be emphasized that boric acid addition is probably not detrimental to tubes and can arrest carbon steel corrosion, it may not be efficient at arresting already-existing crevice conditions that lead to SCC/IGA.

It would be expected, based on laboratory data, that boric acid would have little effect on mitigating SCC/IGA if the electrochemical potential in crevices or sludge piles is high, as would be expected for Cu-bearing sludges. However, all stations using boric acid, whether or not IGA/SCC had continued, had Cu-bearing sludges.

Some stations with mixed-metal secondary piping systems switched from ammonia-based chemistry control to morpholine, and, recently, cheaper, and perhaps also more effective, amines have become available. As of late 1993/ early 1994, several U.S. PWR's have begun using ETA (ethanolamine) as the secondary side pH control additive of choice. One station has recently switched back from ETA to morpholine, following an increase in fouling rate while on ETA.

AVT chemistry control is primarily directed at reducing carbon steel piping corrosion in the secondary piping, and associated components, and hence crud ingress into the steam generator. Because crevices formed under tubesheet deposits and in fouled TSP intersections are considered to be the major cause of localised corrosion resulting in SG tube degradation, minimising deposit formation and impurity ingress is still a major operating and design concern.

Table 1: Location of Pluggable Indications in 1991

Location	Number of Reactors Affected	Number of Tubes Plugged	Percentage of Tubes Plugged
Within Tubesheet	45 (24)*	2030 (1136)	18.5%
Above Tubesheet	73 (29)	1615 (806)	14.7%
U-bend	41 (13)	591 (353)	5.4%
AVB	36 (0)	256 (0)	2.3%
Tube Support Plates	36 (1)	5528 (68)	50.3%
Preheater Region	3 (0)	19 (0)	0.2%
Other	5 (1)	35 (3)	0.3%
Undetermined/ Unknown	50 (0)	918 (0)	8.3%

* Primary-side defects are given in parentheses; i.e., 45 (24) indicates that of 45 reactors with indications at that location, 24 were primary-side indications.

5. Impurity Ingress

Concentration of impurities under deposits is the most likely cause of SG tube corrosion. These impurities enter the SG from the feedwater, and the two main sources of impurity are condenser cooling water in-leakage and water treatment plant upsets. Data on the latter are not readily available, although it should be noted that acid excursions from ion exchange resin treatments are relatively common and have been associated with SG tube degradation. Condenser leaks have been recorded in the survey, and these are shown in Table 2.

Because of the possibly severe consequences of condenser in-leakage most stations are replacing their condensers with stainless steel (lake or river water cooling) or titanium (seawater cooling). It is not possible to practice optimal chemistry control (in particular minimising the transport of crud and copper compounds into the SG) with a mixed-metal secondary system, so an additional benefit of replacing the condenser with an all-ferrous or titanium unit is the ability to practice high pH chemistry control.

6. Sludge Characteristics

Most stations reporting on their sludge do so because they have lanced the tubesheet deposits. If the sludge compositions quoted are for lanced material then water-insoluble species may dominate the composition, but in general the specific data are not as important as the trends. These trends appear to show that most sludges were soft, and that soft sludges are associated with AVT pH control although the fact that most plants now use AVT chemistry control may bias the data. It might be expected that hard sludges would be associated with prior phosphate chemistry, but this is not obvious from the data. It is also likely that soft sludges eventually convert to hard sludge piles, so that a typical sludge pile will develop a hard core surrounded by a softer layer. A note of caution is that the definitions of "hard" and "soft" may vary from station to station.

Table 2: Reported Number of Condenser Leaks from 1982 to 1991

Year	Tube Leaks at Sites using		
	Fresh Water	Sea Water	Brackish Water
1982	113	7	57
1983	297	8	2
1984	307	667	15
1985	120	14	11
1986	43	25	331
1987	37	6	5
1988	479	26	16
1989	357	6	21
1990	109	23	9
1991	125	19	9

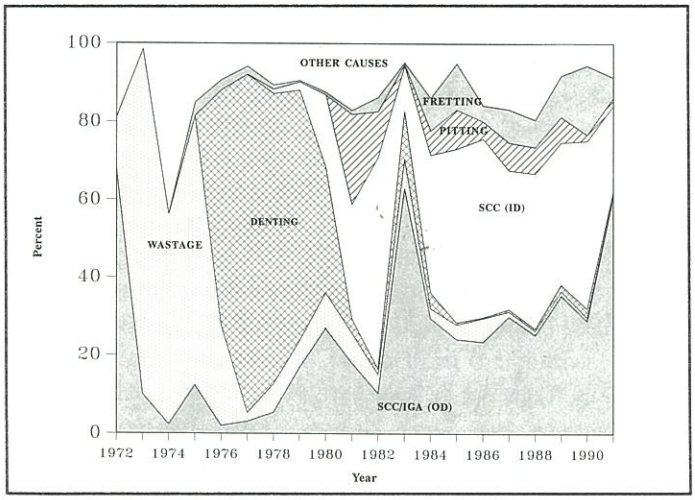
Another correlation that appears to exist is that hard sludge is associated with copper (but copper content is not always an indicator of hard sludge). It has been suggested that the conversion of previously-hard sludge to soft sludge upon changing to AVT chemistry control is possible, however the data in this survey do not support that contention. It was noted that of those stations reporting soft sludge, most have also reported secondary side SCC/IGA. Many of these are using boric acid also, and as noted in Section 4, this has been largely unsuccessful in mitigating SCC/IGA; possibly because the presence of copper raises the electrochemical potential of sludges and deposits. Thus the presence of soft sludge on the tubesheet may not imply non-corrosive conditions, rather it seems to suggest that soft sludges provide an environment in which concentration of impurities can occur, and indeed there appears to be a trend that observations of pitting and IGA are associated with the upper, and probably softest, part of the tubesheet sludge pile.

Clearly the soft sludge should be removed regularly to reduce under-sludge corrosion and to prevent the formation of hard sludge.

These observations are largely anecdotal, and have not been formally captured in the SG database.

Lead has been associated with premature failure of SG tubing, for instance at Bruce-2 and possibly Doel-4, but is present to some extent in many sludges. Recently the SG survey has been surveying sludge characteristics, but lead is usually not listed in the sludge composition analysis.

Figure 1: History of Tube Failure Mechanisms. Note: Approximately 85% of the defects have been caused by corrosion.



7. Conclusions

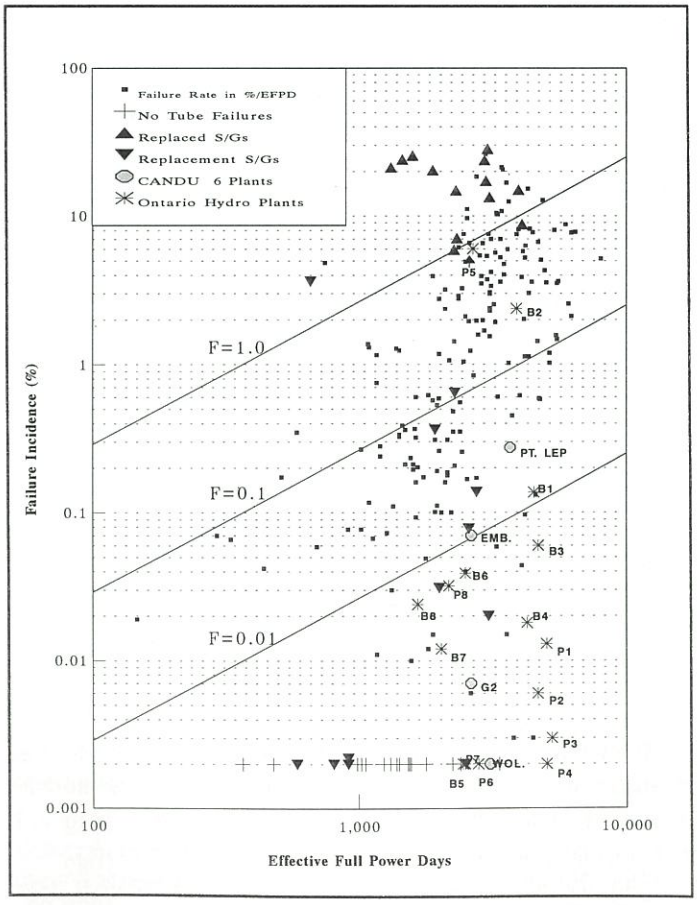
The Figures and Tables of this paper were derived from data generated over the past 20 years or so for the AECL Steam Generator Survey. As we understand more about the causes and consequences of corrosion and fouling, the database has become more useful as a means of testing laboratory predictions with plant data, and as a means of identifying trends that require laboratory work to evaluate. Some of the plant data trends have been unexpected:

- the continuing increase in tube plugging assigned to OD-SCC despite increasingly stringent water chemistry;
- recent incidences of free-span IGA/SCC;
- the apparent ineffectiveness of boric acid in mitigating IGA/SCC.

8. Acknowledgements

The authors would like to thank E.V. Murphy, E.G. Price and P. Spekkens for their valuable comments, and CANDU Owners Group for financial support.

Figure 2: Cumulative Steam Generator Tube Performance Log-log plot of failure incidence versus effective full-power days (EFPD) to the end of 1992. F is failure rate in percent per effective full power year. Those reactors with F>1 may require large-scale repairs or steam generator replacement.



Canadian Approach to Regulation of Steam Generator Safety

Ian M. Grant
Atomic Energy Control Board

Introduction

The Atomic Energy Control Board

The Atomic Energy Control Board (AECB) has, under the Atomic Energy Control Act[1], statutory responsibility for the regulation of uranium mining, nuclear fuel fabrication, construction and operation of nuclear power plants, and industrial and medical uses of radioactivity. The Board consists of a president and four appointed members supported by a staff of about 400 who provide the Board with advice and recommendations on licensing decisions. About two-thirds of the staff work on the regulation of nuclear power plants.

AECB Regulation of Nuclear Power Plants

Underlying the AECB's regulations are the following objectives.[2] First, nuclear activities should not lead to unacceptable risks to workers or the general public.‡ Second, events that lead to the escape of radioactive material or the exposure of people to ionizing radiation should occur with low frequency, decreasing as the severity of the consequences increases, so that the likelihood of catastrophic accidents is virtually zero.

Licensing of each nuclear power plant in practice is based on analysis, documented in a Safety Report, of postulated accidents initiated by failures in the plant or external events.[3] The dose received in consequence by members of the public must meet limits based on the recommendations of the International Commission on Radiation Protection.[4] The dose limits increase as assigned event frequency decreases. The AECB also stipulates that systems that mitigate releases, such as shutdown and emergency core cooling systems, be designed and maintained to achieve high reliability.[5,6]

The ICRP has recently revised its recommendations.[7] Corresponding amendments to the regulations are in progress that will reduce the dose limits for workers and the public.

When plant conditions evolve in ways that the original design and safety analysis did not contemplate, the AECB and its licensees negotiate resolution of safety-related issues. Steam generators are a case in point.

Basis for Regulation of Steam Generator Tube Integrity

Steam generator tubes are important to safety. They form part of the pressure envelope of the reactor primary circuit, so their failure constitutes a small loss-of-coolant accident (LOCA). They also form part of the containment boundary. Since the secondary circuit has pathways leading outside containment, such as the safety relief valves and the condenser air ejector, any radionuclides that pass into the secondary side through tube leaks are available for release into the environment.

Though CANDU steam generators have performed reliably and the overall rates of tube plugging are relatively low (Table 1), evidence of serious steam generator tube degradation has materialized in several CANDU plants. Bruce A Units 1 and 2 have suffered fatigue failures of tubes at U-bend supports due to flow-induced vibration following cleaning. Circumferential stress-corrosion cracking (SCC) also affects Bruce A, and is accelerated in Unit 2 by the presence of lead from shielding inadvertently left after maintenance. Bruce B units have fretting wear at U-bend supports in a fraction of their tubes. Under-deposit pitting and corrosion has caused tube leaks at Pickering and Point Lepreau.

‡ Risk is used in the sense now widespread in science and engineering as meaning the product of the consequences of an event and the frequency of its occurrence.

Table 1: Canadian CANDU Steam Generator Tube Performance

Station	Unit (s)	In-service dates	No. SG Tubes	Approx. % plugged
Pickering A	1-4	1971-73	124,800	0.01
Pickering B	5-8	1983-86	124,800	1.6
Bruce A	1-4	1977-79	134,400	1.1
Bruce B	5-8	1984-87	134,400	0.01
Point Lepreau	1	1982	14,200	0.17
Gentilly-2	1	1982	14,200	0.007
Darlington	1-4	1989-92	74,600	0

The Safety Reports recognize the possibility of tube failures during normal operation and analyze their consequences. In analyzing other accidents, they generally assume that the tubes will withstand any additional loads and will not leak beyond a nominal amount. These assumptions are justified if the steam generator tubes are in the design condition. Clearly they must be re-examined when the tubes are degraded by corrosion, cracking or wear.

Steam Generator Tube Failures During Normal Operation

According to the Safety Reports, rupture of a steam generator tube produces a maximum discharge from the primary to the secondary side between 7 kg/s and 13 kg/s (25,000 to 50,000 kg/hr), depending on the tube size, fluid temperature and pressure, and break location. Leaks are usually much less severe than this. Still, the limiting rates are well within the make-up capacity of the primary system, so the plant can be brought to an orderly shutdown with little risk of the fuel overheating or of significant releases. Even if a few tubes completely ruptured during normal operation, the dose received by the public would be within limits as long as the radionuclide concentration in the primary fluid is at normal levels.

Steam Generator Tube Failures During Postulated Accidents

Some postulated accidents challenge the strength and continuity of steam generator tubes, and have the potential to increase existing leaks or to cause previously non-leaking tubes to leak. A Main Steam Line Break (MSLB) quickly empties the steam generator and puts additional drag, differential pressure and vibrational forces on the tubes in the U-bend area. Feed-water Line Breaks (FWLB) can also stress the tubes in units with integral preheaters. These events put the greatest loads on the tubes, so set the mechanical design basis.

LOCAs such as rupture of a fuel channel inlet feeder pipe can result in fuel failures while the system remains at high pressure. The safety system response to such an event includes automatically opening the relief valves to depressurize the steam generators and quickly cool the reactor. The elevated density of fission products in the primary coolant reduces the tolerable leak rate, and it is important that the steam generator tubes maintain their integrity during this transient loading to prevent bypassing of containment and release of fission products from the station.

LOCAs and pipe breaks have proved to be the cases that define the permissible degree of tube degradation in affected plants.

Acceptance Criteria for Degraded Steam Generator Tubes

To maintain the validity of the Safety Report, two options exist: (i) to show that steam generator tubes retain their integrity under accident loads despite the presence of flaws; or (ii) to demonstrate that the consequences of potential failures meet established limits.

(i) Justification by Demonstrating Tube Integrity

Steam generator tubes in most plants are strong compared to the expected accident loads. Burst pressures for tubes in CANDU units typically range from 80 to 100 MPa (12,000 to 14,000 psi), approximately seven times the working pressure. These strength margins are reflected in acceptance criteria for degraded tubes that tolerate large flaws.[8,9,10,11]

AECB staff have accepted definitions, developed by its licensees, of maximum tolerable flaw size (MTFS) based on ductile collapse of flawed tubes which meet the factors of safety in Section III of the ASME Boiler and Pressure Vessel Code. This approach for example has yielded an MTFS of 81% wall loss for fretting at Bruce B.[12] From the MTFS are subtracted allowances for measurement error E and flaw growth during the planned inspection interval $G\delta t$, according to the formula below, to arrive at a plugging criterion.

$$A = MTFS - E - G\delta t$$

To ensure tube integrity for a two-year planned inspection interval, with fretting wear rates measured up to 8% per year, and eddy-current measurement errors around ±10% of wall thickness, this formula requires plugging tubes with frets exceeding 55% of through-wall.

Similar procedures have been applied to other defect types. MTFS for circumferential SSC at Bruce A is defined as 166° long for through-wall cracks or 75% through-wall for surface cracks.

(ii) Justification by Assessing Consequences of Tube Failure

Corrosion or wear can be measured with reasonable accuracy by routine examination with eddy-current "bobbin" probes, but this method is unsuited to detection of tight, circumferential stress-corrosion cracks.[13] Even after inspection with state-of-the-art probes, such as the Cecco-3, of a population of steam generator tubes containing such cracks, there is a probability that some may remain that could leak during an accident.

In view of the limitations of current NDE methods, AECB staff have accepted cases for return of units to service that consisted of probabilistic estimates of the numbers of remaining flaws, calculation of the potential leak rate, and comparison with the regulatory dose limit. These cases were supported by removal of large samples of tubes and rigorous demonstration of the probability-of-detection capabilities of the non-destructive examination (NDE) procedures.

The leak rate that just meets the current regulatory dose limit under MSLB or small LOCA with fuel failures is of the order of 1 to 2.5 kg/s. Leak rates rise over a wide range with increasing crack size, as illustrated in Figure 1, and this is much less than the discharge rate from a single severed tube.

Furthermore, the permissible leak rate will decrease under the new regulations. In practical terms this means that only small, tight cracks can be accepted, and that large cracks or tube ruptures are not tolerable.

CANDU plants routinely monitor steam generator leakage with methods capable of detecting leaks below 10^{-3}kg/s. Plant operating procedures require shutdown when the leak rate exceeds a specified limit, usually 15 kg/hr (4×10^{-3} kg/s). At Bruce A, most leaking cracks have triggered shutdown before they reached the MTFS. However, the correlation between crack size and predicted leak rates is usually poor, as

exemplified by Figure 2, because of the dependence of leak rate on confounding variables such as applied loads, locked-in stresses from support displacement, crack morphology, the presence of thin ligaments that block the crack, and blockage by crud or particulates.[14,15,16,17] Instances are recorded in Figure 2 where cracks grew beyond the MTFS before reaching the shutdown leak rate. Furthermore, leak monitoring obviously can not detect surface cracks that grow beyond a critical size before penetrating the tube wall.

Figure 1: Predicted leak rate from 13 mm (0.5-inch) OD steam generator tubes under MSLB conditions. Based on finite element estimates of crack opening followed by thermalhydraulic calculations.

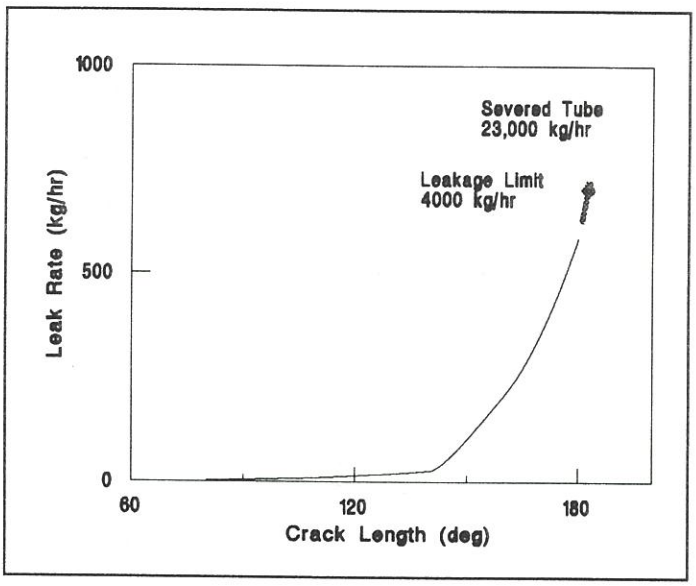
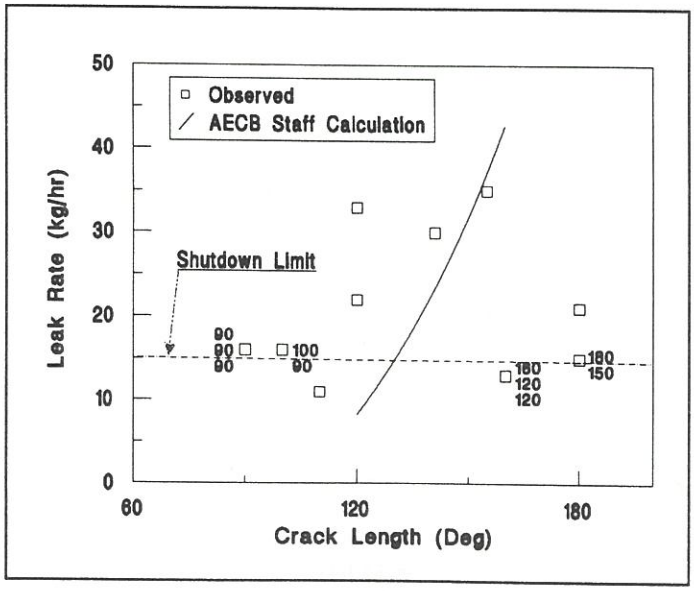


Figure 2: Leak rates from 13 mm (0.5-inch) OD steam generator tubes during operation. Numbers beside points denote multiple leaking cracks.



AECB staff consider that leak monitoring is a useful precaution, but one that, by itself, does not preclude the existence of large flaws or tube ruptures, and, that non-destructive examination is necessary to ensure that acceptance criteria are met. The lack of tolerance for tube failures demands continued improvements in the accessibility, speed, accuracy and performance demonstration of NDE methods for steam generator tubes.

Tube Plugging and Repair

Tubes with unacceptable defects until now have been plugged. Plugging large numbers of tubes is not covered in the Safety Reports and represents a significant deviation from the conditions for which the reactor was designed and licensed. There are possible implications for reactor physics, thermalhydraulics of normal operation, trip coverage and safety system effectiveness, and the integrity of components such as the divider plates and tubesheets.

Additional analysis may be required to demonstrate safe operation of the units with large numbers of plugged tubes. These factors may eventually determine the safe life of the steam generators unless other non-destructive repair methods are developed.

Future Considerations

Many steam generators have degraded in ways that their designers failed to anticipate. One might hope that predictions of materials performance will work better in future, but it has also been proposed that some corrosion systems possess dynamics that are predictable in the short term, yet whose evolution over the long term is inherently unpredictable.[18]

As engineers we should not rely on perfection of designs for acceptable performance. It is important to find ways of making steam generator designs tolerant to failure. This should include reducing the impact of tube degradation on safety, especially the response to accidents elsewhere in the plant. Adequate inspection and repair methods and leak detection are also critical to continued operation with degraded tubes.

AECB Research Projects

The AECB supports a programme of research whose projects are usually aimed at getting independent expert advice on technical matters or carrying out experiments that furnish information needed to assess the validity of a safety case.

Recent projects have included expert review of acceptance criteria for tubes affected by fretting at Bruce B, procedures for chemical cleaning of steam generators at Bruce A and Pickering, and disposition of stress-corrosion cracking at Bruce A. Currently a project is under way to develop a regulatory position on the possible content of fitness-for-service guidelines for steam generator tubes. Another proposal is being developed for experiments to investigate the dynamic response of defected tubes under MSLB loads.

Conclusions

1. Steam generator tubes are important to safety of nuclear power plants – they are not only an economic problem.
2. The response to postulated accidents initiated by failures

of other components has defined the permissible degree of tube degradation in affected CANDU plants.

3. A ductile limit-load approach has proved successful in defining maximum tolerable flaw sizes, and shows that relatively large flaws can be present without damaging tube integrity.
4. When tube integrity is uncertain, assessment of the consequences of leakage has been used to justify continued service. However, the tolerable leak rates may not permit the existence of large defects or tube ruptures.
5. Leak rate monitoring is a useful precaution for intercepting defects, but on its own it does not preclude the existence of flaws that could leak beyond the limits in the event of an accident.
6. Assurance that steam generators continue to meet the licensing conditions throughout their life can only be obtained through detailed monitoring and management of their condition. The lack of tolerance to tube failure demands continued improvement in non-destructive examination methods to verify that steam generator tubes meet the acceptance criteria.

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CNS Financial Statements for 1993

Ed. Note: *Although the term of office of the Council and Executive of the CNS runs from AGM to AGM (usually in June) the fiscal year is the calendar year.*

Auditors' Report

To the Members of Canadian Nuclear Society

We have audited the balance sheet of the Canadian Nuclear Society as at December 31, 1993 and the statements of operations and surplus for the year then ended. These financial statements are the responsibility of the Society's Council. Our responsibility is to express an opinion on these financial statements based on our audit.

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

In our opinion, these financial statements present fairly, in all material respects, the financial position of the Society as at December 31, 1993, and the results of its operations for the year then ended in accordance with generally accepted accounting principles.

Toronto, Canada
March 25, 1994

Chartered Accountants

Detailed financial statements follow on the next page.

1993 Financial Statements

Canadian Nuclear Society Statement of Operations	Year Ended Dec. 31, 1993	11 Mos. Ended Dec. 31, 1992
Income		
Membership fees	$ 37,557	$ 33,914
Publications	7,590	4,269
Interest	7,642	7,038
Other	-	6,870
Loss on sale of investment	-	(10,712)
	52,789	41,379
Society Projects – excess of income over expenditures		
Annual Conference (INC in 1993)	21,300	15,188
International Simulation Conference (Simulation Symposium in 1992)	29,379	4,863
Fusion Seminar – April	450	-
Reactor Safety Course – May	5,271	-
Rolled Joint Conference – September	13,000	-
1992 CANDU Maintenance Conference	(2,804)	61,414
1992 CANDU Fuel Conference	1,082	7,021
1992 Regional Overpower Trips Course	82	4,225
Recovery of prior year Education Fund Expenditures	3,500	-
	71,260	92,711
	124,049	134,090
Expenses		
Net expenditures by Branches	11,654	6,720
Committees		
Membership	1,336	14,780
Program	1,352	1,058
Awards	739	1,168
Education and Public Affairs	2,040	-
	5,467	17,006
Office Support	32,000	27,500
Office services		
Audit fees	3,000	2,880
Canadian Nuclear Society Council expenses	4,536	3,276
Stationery and office supplies	2,619	4,716
Bank charges	399	906
Credit card charges	1,243	-
Computer programming	97	553
Telephone	1,843	1,525
Postage	14,344	13,016
Copying facilities	2,400	2,000
Courier charges	155	351
	30,636	29,223
Canadian Nuclear Society Bulletin	18,906	26,344
Special Projects		
Student Conference	892	1,500
International Nuclear Societies	-	687
	892	2,187
	99,555	108,980
Excess of income over expenses	$ 24,494	$ 25,110
Statement of Surplus		
Surplus, beginning of period	$ 183,788	$ 158,678
Excess of income over expenses	24,494	25,110
Surplus, end of period	$ 208,282	$ 183,788

Canadian Nuclear Society Balance Sheet December 31	1993	1992
Assets		
Current		
Cash		
Royal Bank	$ 20,423	$126,903
Nuclear Science and Engineering Divisions	7,168	6,869
Branch bank balances	15,454	14,605
Wood Gundy	68,417	-
Bank of Montreal	22	66
Receivables	48,022	52,424
Prepaids	-	691
Marketable securities (Note 1b)	69,924	93,403
Conference advances	5,000	6,000
	234,430	300,961
CNS share of Education Fund assets (Note 2)	12,000	12,000
	$246,430	$312,961
Liabilities		
Current		
Payables and accruals	$ 6,905	$ 48,728
GST payable	4,023	-
Membership fees received in advance	28	11,892
Due to Canadian Nuclear Association	15,192	56,553
	26,148	117,173
Surplus		
Accumulated surplus	208,282	183,788
Education Fund (Note 2)	12,000	12,000
	220,282	195,788
	$246,430	$312,961

On behalf of the Canadian Nuclear Society Council

Canadian Nuclear Society
Notes to the Financial Statements December 31, 1993

1. Summary of significant accounting policies

(a) Revenue Recognition

Membership fees are included in income in the fiscal year to which they relate. Interest and other income is recorded on the accrual basis.

(b) Marketable securities

Market value approximates cost. These investments are carried at cost adjusted for amortization of premiums or discounts.

(c) Change in year end

The Society changed its year end to December 31 from January 31 effective December 31, 1992. Accordingly, the comparative 1992 financial statements cover an eleven month period.

2. Education fund

From 1988 to 1991, annual contributions amounting to $3,000 from the Society and $7,000 from the Canadian Nuclear Association were allocated from the income from the annual conference. The interest on these funds is available for educational purposes to the local branches of the Society. The principal remains the property of the CNA and the Society.

The total fund is composed as follows:	1993	1992
Principal contributions		
Canadian Nuclear Association	$ 28,000	$ 28,000
Canadian Nuclear Society	12,000	12,000
	40,000	40,000
Accumulated interest available to Canadian Nuclear Society local branches	12,015	15,199
	12,015	15,199

CNS Annual General Meeting

About 40 members turned out for the 1994 Annual General Meeting of the Canadian Nuclear Society held in Montreal on June 7, during the annual CNA/CNS conference.

Given the lack of controversial topics and of an election (only the basic slate was nominated) that attendance was remarkably good and higher than in recent years.

Following the usual format, the minutes of the 1993 AGM were accepted followed by the Treasurer's report and the accompanying auditor's report on the Society's finances. (The latter is printed elsewhere in this issue of the *Bulletin.)* Reports from the various committees outlined the active year which was summarized in Paul Fehrenbach's outgoing President's address (also reprinted below).

The only unusual item was a proposal and offer from Ed Sawchuk to help the Cree band of northern Québec in their opposition to the Great Whale hydroelectric project. Outgoing President Paul Fehrenbach and others felt this was too sensitive an issue which could be seen as supporters of one technology attacking another.

The new executive and Council, as nominated by the Nominating Committee and presented to members in the spring, were acclaimed.

1994-95 CNS EXECUTIVE AND COUNCIL EXECUTIVE

President	Ed Price	AECL CANDU
1st Vice-president	Jerry Cuttler	AECL CANDU
2nd Vice-president	Hong Huynh	Hydro-Québec
Secretary	Stefan Kupca	AECL Research (CRL)
Treasurer	Ben Rouben	AECL CANDU
Past-President	Paul Fehrenbach	AECL Research (CRL)

MEMBERS AT LARGE

Jean-Claude Amrouni	ENAQ
John Hewitt	Natural Resources Canada
Paul Ingham	AECL Research (WL)
Ed Jeliniski	Ontario Hydro (Darlington)
Jeff Lafortune	SAIC Canada
Fran Lipsett	AECL Research (CRL)
Aslam Lone	AECL Research (CRL)
Surinder Singh	Society of Prof. Eng. & Assoc.
Ken Smith	UNECO
Shayne Smith	Wardrop Engineering

President's Annual Report

In spite of the continuing turbulent times in the Canadian Nuclear industry, I am pleased to be able to report that the Canadian Nuclear Society had another successful year. Other members of council will be reporting in more detail on their portfolios, so the following is a brief report on what I consider to be the highlights of the year. At last year's AGM, I set four priorities for myself and council:

1. Increase the public profile of the Canadian Nuclear Society through local Branch activities.

I think we have been successful as you will hear in the Branch report by Jerry Cuttler. The number of events organized by CNS Branch have continued to increase, and many of these have been of a general nature to which the public has been invited. We no longer are spending so much time talking only to ourselves, and media coverage of these more public events is very effective in raising the public profile of the Society. The degree of Branch involvement with their local school systems has also increased, and we are making effective use of the CNS/CNA Educational Fund for this purpose. These projects range from sponsorship of prizes at science fairs, and providing speakers to local high schools, to assisting teachers develop experiments demonstrating radioactivity and radioactive decay. The Education and Public Affairs Committee, through Aslam Lone, has now established a resource kit of materials and video tapes for use by high school teachers and our local Branches now need to publicize its availability.

2. Achieve a 15% increase in membership.

Although we attracted about 81 new members again this year, our actual membership growth was less than 8%, and we need to continue working to understand and address the reasons why more members do not renew their membership. We have made progress in this area with the realization that we were not focusing on meeting the needs of one of the largest segments in our industry, the men and women who operate our nuclear power plants. We have now addressed this by the formation of a new Nuclear Operations Division, and are working to establish CNS Branches at the stations. We are also continuing to try to understand the needs and desires of our members and potential members through initiatives such as the membership survey which you have recently received. So although we did not fully achieve our target for membership increase, I think we are moving in the right direction, and Council has taken some important decisions which will have a large positive impact on membership in years to come.

3. Increase the participation and level of activity in the Technical Divisions

The major goal here was to ensure that all of our technical divisions were active in promoting technical activities and conferences of interest to the membership, and that we had

people leading the divisions who were enthusiastic and able to provide the effort required. I think we have achieved our goals for the year, but this will be a continuing challenge for every council. I am happy to tell you that Mitch Ohta, the Manager of the Underground Research Laboratory at the Whiteshell Labs of AECL Research, has agreed to Chair the Waste Management and Environmental Affairs Division and with the help of the Manitoba CNS Branch executive has underway the planning and preparations for the 1995 International Waste Management Conference. Of course, the highlight of the year with respect to Technical Divisions was the previously mentioned formation of the new Nuclear Operations Division.

4. Work to ensure the success of INC '93

This for me was one of the real highlights of the year. INC '93 was a tremendous success, attendance met and exceeded expectations, and most of the comments received, particularly from International attendees were very positive. I am extremely proud of the CNS role in the organization and operation of this conference, led by Ben Rouben and Gil Phillips, and other of our members who served on the organizing committee, and I think we should all take pride in the success of this major International conference.

In the committee reports which follow, you will hear in greater detail of these and other Society accomplishments over the past year. The committees of Council were very active in pursuing their respective responsibilities, and that has also been an important aspect of the year from my perspective. The Finance Committee has been re-established, the Program Committee has done an excellent job with Seminars, Workshops and Conferences, especially this 15th Annual Conference, the Branch Affairs Committee as noted above has developed a new format for the membership directory, has just issued a membership survey, and is on the brink of a significant increase in membership, the honours and awards committee has recommended, and the council approved, three new admissions to the honorary membership category known as Fellow of the Canadian Nuclear Society, and the recipient of the 1994 Innovative Achievement Award. The Education and Public Affairs Committee continues to provide and support excellent projects, and the International Liaison Committee has been active in arranging co-operative agreements with sister societies, and in participating in projects of the International Nuclear Societies Council such as the statement on sustainable development, the adoption of a Global Creed, and in drafting of a vision for the next fifty years of nuclear energy. Finally, I would like to again pay tribute to the continued excellence of our Canadian Nuclear Society *Bulletin*, edited by Fred Boyd with assistance from Ric Fluke. The new format just introduced has improved the quality even more.

In terms of these activities, and of the goals and priorities I established for myself and Council last year, I think we have together made significant achievements. Your 1993/94 Council was a very strong one with many dedicated members who worked hard on your behalf. I have very much enjoyed the opportunity to work with them to serve you and to further the aims and objectives of the Canadian Nuclear Society, and I leave office with a sense of accomplishment on behalf of both myself and of council.

Paul Fehrenbach

Incoming President's Report

The industry of which we are part has seen a severe contraction in the past couple of years. The downsizing of the economy and the recession have flattened electricity demand and caused difficult debt servicing problems for Canada's largest utility. The necessary corrective measures have resulted in a significant reduction in the workforce of that utility, and it is unlikely that there will be a significant increase in demand in Ontario or elsewhere in Canada in the 1990's, that could not be satisfied from existing capacity. This somewhat disappointing domestic scenario, which is relieved partly by the need for servicing work on the operating domestic reactors, is made more disappointing by the reduction in work on existing export orders, which have peaked in demand earlier this year.

What does this mean for our members? We could interpret it as a time for our members to take a breather. However we should look at the view before we take a breather. What we see is an enormous potential demand centred in Asia that to satisfy even a small fraction of this demand, could stretch the limits of Canada's nuclear industry's capacity. We also see the CANDU reactor as an exciting machine with its possibilities for the use of a wide range of fuels, the ideas for which have been around for a while but the drive for their development and use has been stimulated by the need to reduce fuel disposal concerns. The foregoing is the situation that our members find themselves. Different targets and an intensely competitive export environment.

A lot of engineering support will continue to be required from our members to ensure the operating plants maintain their reliability and capacity figures as the plants increase in service life. To this end the formation of the Nuclear Operations Division is timely, and will provide the members of that division the vehicle to develop events or courses that are of particular interest to their training and understanding in dealing with the problems associated with maintaining high capacity performance.

I see a greater degree of enthusiasm in the nuclear community than in past years for what our society can provide. We have a stronger branch activity than we have had in the past years, and we should record our appreciation of the work that Jerry Cuttler has put into Branch activities. We have a strong conference / workshop program, well supported and with a high percentage of offshore support that is a measure of the quality of the events. We seem to be seeing an end to the drought in Ontario Hydro attendance at CNS events caused by its restructuring activities and financial strictures. As an important feature of the next few years' activities, I believe the Society should aim for a greater international profile and participation at this annual conference than is currently being achieved. The quality of the papers over the past 6 or 7 years has reached and been

maintained at a high level. We should target for the level of international participation that was achieved at INC '93.

Our membership needs to grow. We are making solid progress in this area, and the strong efforts of the Membership committee will induce more of the technical community to join the Society. But all members should take on the responsibility for joining up their colleagues.

Financially, the Society is on relatively solid ground and we have come through the last few years showing a steady growth in our members' equity. This has been achieved through considerable voluntary effort by conference and workshop activities. Without this volunteer effort we would be a much lesser Society. Yet even as we grow we must continue to grapple with the problems of ensuring adequate office support to our activities and counter the effects of the cutbacks the CNA found necessary to remain viable financially. With regard to office support, I would like to thank Kathy Murphy and Angeline Laughlan for their support to the Society's activities and wish them well in the future.

The *Bulletin* is our most prominent communication to our members, and we greatly appreciate the work Fred Boyd puts into it. We join in congratulating Fred on becoming a Fellow of the Society – a deserved honour.

I am cognizant of the fact that I come into this office following presidents who have infused significant change into the operation of the CNS. I've enjoyed working with them and I hope the next council will find its participation as interesting.

I would like to thank Paul for his direction and hard work over the past year as president. We expect his presence at this year's council meetings will continue to be a source of reasoned and knowledgeable opinion.

We look forward to another satisfying year.

Ed Price

Science for Educators Seminar

Over 120 teachers from all across Canada took part in the 19th Science for Educators Seminar held in Pembroke and Chalk River, April 14 to 16. Members of the CNS Chalk River Branch were active members of the "faculty" for the seminar which is sponsored by AECL Research, Chalk River Laboratories.

Thursday, April 14, was a "pre-seminar" day with tours of CRL and sessions conducted by John Hilborn and Aslam Lone on "Introduction to Nuclear Technology" and "Hands-On Experiments with Ionizing Radiation". The latter, an innovation this year, was very popular with the teachers.

The next day Richard Osborne presented the opening lecture of the actual seminar on "The Science of Radiation Protection". Following was a day and a half full of lectures and workshops on various aspects of nuclear technology, ending Saturday morning with a talk by Joe Borsa on "Radiation Applications in Modern Life" which elicited many questions on food irradiation.

The popular seminar will be presented again next spring.

Ottawa area high school students pose at the Chalk River Laboratories during trip sponsored by the CNS Ottawa Branch at the end of June 1994.

CNS Council 1994-95

ANS Annual Meeting

The annual meeting of the American Nuclear Society in New Orleans the third week of June was a large affair; with 1100 attendees it was over twice the size of the CNA/CNS conference in Montreal two weeks earlier but was much more subdued. With the US nuclear power program continuing in the doldrums, the ANS facing financial problems, and no specific focus to the meeting (other than the "embedded" topical meeting on "Technology of Nuclear Fusion") the mood was almost sombre.

There was still much activity, with 12 or more parallel technical sessions, a plethora of committee meetings, a small exhibition and a couple of enjoyable social events. A dinner cruise on a Mississsippi steamer and an evening at a traditional Cajun Dance Hall provided some of the distinct flavour of the New Orleans scene. Nevertheless, it would be impossible for anyone to see or experience more than a corner of this multi-ring event.

A small number of Canadians attended; some giving papers, some on the ANS Board or committees, some receiving awards and some just there.

The opening plenary session set a strange tone by juxtaposing a political commentator with an executive from France and a physicist from the US fusion program. Only Michel Lecompte, CFO of Framatome, came close to the theme of the meeting "achieving competitive excellence". The commentator's remarks were largely unrelated to the nuclear see but she still drew considerable response from the predominantly American audience. Dr. John Nuckolls, of the Lawrence Livermore laboratory, addressed both the future of fusion (especially inertial confinement) and the proliferation problem of plutonium from the weapons programs (especially of the former USSR). The latter set the stage for the "embedded" topical meeting on "Technology of Fusion Energy" and considerable discussion within the ANS on the weapons plutonium issue.

Don Hurst receives the "Tommy Thompson Award" at the ANS Annual Meeting in New Orleans in June 1994.

A special session was held in memory of Dr. Dixie Lee Ray, a onetime Chairperson of the United States Atomic Energy Commission (before its functions were split between the Department of Energy and the United States Nuclear Regulatory Commission) and focused on opening the files on early US radiation testing of human subjects.

Another special session dealt with "people issues" of the proposed Yucca Mountain high level waste disposal facility. Although most residents of Nevada had supported bomb tests in the 1950s and 1960s many now object to what they perceive as the dumping of other people's radioactive garbage in their state.

The 30 member ANS Board of Directors (on which two Canadians sit – Stan Hatcher and Peter Stevens-Guille) met for most of two days primarily wrestling with a significant operating deficit arising from a drop of advertising income.

Former CNS president Ken Talbot assumed the chair of the large ANS International Committee from John Graham (onetime with AECL Research) who was elected vice-president/president-elect of the ANS. At that committee meeting and in other discussions, CNS vice-president Jerry Cuttler obtained general agreement for an arrangement whereby CNS student members could share benefits of an ANS student branch.

Several Canadians received awards at various functions during the meeting. Herb Inhaber, onetime with the AECB was given a leadership award; Françoise Guenette (former AECL vice-president) won an award for her paper at the ANS winter meeting last November; and Don Hurst, former president of the AECB, was presented with the Tommy Thompson Award for his work in nuclear safety.

At a meeting of the ANS Radiophamaceutical and Isotope Production Committee there was further discussion of the ANS role in urging the US government to build its own isotope production reactor. The ANS has already joined with a number of other societies in an Alliance for American Isotope Production and have submitted a brief to DoE. Although not stated in any document a major initiating factor in these moves is the on-going dispute between AECL and Nordion and AECL's cancellation of the Maple reactor.

In the technical sessions over 400 papers were presented. Separate "transactions" for the ANS meeting and the Fusion Technology Meeting, containing 500 word summaries, are available from the ANS.

Hurst Receives Safety Award

Dr. Donald G. Hurst was presented with the "Tommy Thompson Award" for contributions to reactor safety at the annual meeting of the American Nuclear Society in New Orleans on June 22, 1994.

Don Hurst is one of Canada's nuclear pioneers, starting his involvement with the Montreal Laboratory during World War II. Moving to Chalk River he became one of the senior persons in reactor physics and design and conducted the major review of the NRX accident of 1952. In the late 1960s he was Director of the IAEA's Division of Nuclear Power.

In 1972 Dr. Hurst was appointed president of the Atomic Energy Control Board where he stayed until his retirement in

1976. Following his retirement he was appointed chairman of the Senior Review Group for the IAEA's nuclear safety standards program. He remains active in various ways, including being a member of Ontario Hydro's "Technical Advisory Committee on Nuclear Safety" and having a major role in the preparation of a technical history of nuclear research in Canada.

The award consists of a special plaque and a cheque for $1,000 (US).

The citation for the award reads:

For distinguished leadership in the formative years of the Canadian CANDU reactor program and then as the International Atomic Energy Agency's director of the Division of Nuclear Power and Reactors. As President of Canada's Atomic Energy Control Board and chairman of the Reactor Safety Advisory Committee you led in the establishment of the policy of diverse and independent full capability reactor protective systems for CANDU reactors and pioneered in the extension of reactor safety analysis to include probabilistic safety assessment of systems important to safety. Later you had a key role in the establishment of the IAEA's NUSS program of international reactor safety standards.

At the same ceremony Dr. Warren Nyer, a member of Fermi's team for the first reactor and subsequently in charge of safety related work at Oak Ridge, Idaho Falls and Hanford, was presented with the "George Laurence Award" also for contributions in nuclear safety. That award is named after Dr. George C. Laurence who was also a Canadian nuclear pioneer and president of the Atomic Energy Control Board from 1962 to 1971.

Branch Activities

Ed. Note: *Much of the following has been drawn from the annual report by Branch committee chair Jerry Cuttler for the CNS Annual General Meeting.*

New Branch Being Formed

The first steps have been taken to form a new CNS branch at Pickering NGS. Through the initiative of CNS vice-president Jerry Cuttler, an inaugural meeting was held in mid-May and an initial pro-tem executive established with Wally Cichowlas as chair, Laurie Swami, secretary, Eduardo Lopez, treasurer and John Marczak, communications. Preliminary plans have been developed for a number of meetings to be held in the fall and for other activities with the local community.

With the creation of a Branch at Pickering NGS it is likely that the Central Lake Ontario Branch will become the Darlington Branch.

Both the **Bruce** and **Central Lake Ontario Branches** had reduced activities over the 1993-94 season as a result of the preoccupation of members with the Ontario Hydro restructuring. Two meetings were held at Darlington NGS, one in September, in conjunction with a CNS Council meeting, when Dr. Jathin Nathwani gave a presentation on "Perceptions and Management of Risk", and the other in March with Jerry Cuttler speaking on "RBMK Safety".

Chalk River

The CNS Chalk River Branch had a full program of speakers over the season: Francoise Guenette on public affairs; Bruce Howe on the future of AECL; Len Hopkins on science; B. MacGillvary on radioisotopes in medicine; J. Cramer on the Cigar Lake analogue study; R. Mitchell on the risk of radiation.

The Branch also had a very active eduction program including participation in the Science for Educators Seminar, the Deep River Science Academy and provision of equipment and prizes to area high schools.

Golden Horseshoe

The CNS Golden Horseshoe Branch, based at McMaster University, also ran a full program of speakers: K. Kozier on WR-1; K. Hori on advanced x-ray and gamma-ray techniques for void measurement; S. Sugiyama on current research at NUPEC; F. Kaminaga on flooding analysis; E. Kalinowski on influence of reversion time in heat exchangers; J. Cuttler on RBMK safety and T. Ueno on thermohydraulic problems in steam generators.

The Branch also sponsored a tour to Pickering NGS and participated in activities for the 35th anniversary of the McMaster Nuclear Reactor.

Manitoba

A number of talks were held by the CNS Manitoba Branch by S. Hatcher on energy and ethics; D. Greenberg on radiation medicine; J. Cuttler on RBMK safety; J. Reid on the federal Environmental Assessment Act.

The Branch arranged a visit to the Nuclear Medicine Facility of the Health Sciences Centre in Winnipeg and is helping to plan the 1995 CNA/CNS Student Conference and the CNS International Waste Management Conference to be held in the fall of 1995.

New Brunswick

The CNS New Brunswick Branch had an active program of speakers; B. Baskette on training at Point Lepreau NGS; V. Marculescu on the Cernavoda project; D. Weekes on Lithuania and Korea; H. Storey and P. Ahearn on SLAR; J. McCarthy and D. Reeves on simulator based training. The annual dinner meeting had both J. Cuttler speaking on RBMK safety and R. Keating on CANDU marketing initiatives.

Ottawa

A number of meetings were held with a variety of speakers: J. Levesque on the Ernst and Young study; C. Allen on the nuclear waste disposal; concept; D. Rogers on medical dosimetry techniques (with local members of the CRPA invited); and J. Cuttler on RBMK safety. Bob Nixon, the recently appointed chairman of AECL was the guest speaker at the annual dinner meeting in May.

The Branch has become active in educational activities; participating on the organizing committee for the regional Science Fair and sponsoring a tour for high school students to the Chalk River Laboratories in June.

Quebec

The CNS Quebec Branch held two meetings, one in Montreal with M. Goldman speaking on radiation lessons from Russia and the other at Gentilly with Pierre Charlebois (director of Pickering NGS) on challenges facing Ontario Hydro Nuclear.

Saskatchewan

The CNS Saskatchewan Branch sponsored two special programs, one emphasizing women in science with K. Strauss and another one focused on schools with C. Gold.

Arrangements are being made for the W. B. Lewis lecture which will be held in Saskatoon this fall.

Toronto

The CNS Toronto Branch again ran its series of public lectures: J. Fox on Ontario Hydro's new focus; F. Nolan on good science in plain language; D. Oates on opting for cooperation in siting ; A. Dickenson on the AMPCO perspective of Ontario Hydro; H. McCormack on DNA in criminal cases; and S. Conway on Ontario Hydro.

Members of the Branch were very involved in the CNA/CNS Student Conference held at U. of T. in March.

News of Members

Dr. Mamdouh Shoukri has been named Dean of Engineering at McMaster University as of 1 July 1994. He had been Chair of the Department of Mechanical engineering since 1990.

Dr. Shoukri came to McMaster University from Egypt as a graduate student in 1972 and obtained his PhD. in 1977. He then spent seven years with Ontario Hydro research becoming head of the thermofluids unit. He returned to McMaster in 1984 as an Associate Professor.

His research has been in the field of thermofluids as applied to nuclear reactor safety. He has been an active member of the CNS and is also a member of the PEO and the American Society of Mechanical Engineers.

Shayne Smith has been appointed as a Principal in the firm of Wardrop Engineering Inc.

Shayne is involved in the design and analysis of nuclear systems and components and in the assessment and application of other advanced technologies.

Within the CNS Shayne has been chair of the Education and Public Affairs Committee and in the organization of CNA/CNS Fusion activities.

Ken Talbot has been elected as chair of the International Committee of the American Nuclear Society.

Director of Bruce 'A' NGS as his full time job, Ken is a former president of the CNS and for the past few years has been chair of the CNS International Committee.

He took on his new task at the ANS Annual Meeting in New Orleans in June.

Elgin Horton, former Ontario Hydro vice-president for nuclear operations, was presented with the Ian McRae Award for significant contributions to the nuclear industry, at the CNA/CNS Annual Conference in Montreal in June.

Terry Rummery, president of AECL Research, was awarded the W.B. Lewis Medal by the Canadian Nuclear Association at the CNA/CNS Annual Conference in Montreal, 7 June 1994. (See separate article.)

Division Renamed

With the creation of the Nuclear Operations Division the CNS Council decided that the former Mining, Manufacturing and Operations Division should be renamed.

After considering a number of suggestions Council chose: **FUEL TECHNOLOGIES DIVISION**, as the new name.

Al Lane, of AECL Research, Chalk River Laboratories, remains as chairman of the renamed division.

CNA Awards

As usual the Canadian Nuclear Association presented a number of awards at the CNA/CNS Annual Conference in Montreal in June.

The prestigious **W. B. Lewis Medal** for significant scientific or engineering contribution in nuclear endeavour was presented to **Dr. Terry Rummery**, currently acting president of AECL.

The other top award, the **Ian McRae Award**, for major contributions other than scientific, went to **Elgin Horton,** former vice-president, nuclear operations at Ontario Hydro.

Outstanding Achievement Awards were presented to:

Ray Silver for 50 years of sound, responsible, reporting on the Canadian nuclear scene;

Adi Dastur for innovative work on reactor physics; and

Don Charleworth for his work in nuclear chemistry.

A special **Group Outstanding Achievement Award** was presented to the **Pickering NGS #7 "A" team** for their contribution to Pickering #7 achieving the record for longest continuous operation of any nuclear power plant in the world.

Terry Rummery is presented with the CNA W.B. Lewis Medal at the CNA/CNS Annual Conference in Montreal, June 1994.

CNS Honours and Awards for 1994

The following award and honours by the Canadian Nuclear Society for 1994 were presented during the CNS Luncheon on June 7, 1994 at the 1994 CNA/CNS Annual Conference held this year in Montreal.

Innovative Achievement Award, 1994

The Innovative Achievement Award was established by the CNS in 1991. Recipients of the award are specially recognized for: *"significant innovative achievement in the implementation of new concepts in the nuclear field in Canada."* The award trophy, on which all recipients' names are inscribed, is in the form of an original sculpture showing three figures supporting the Society's logo. Each recipient retains a miniature. In 1994 the Innovative Achievement Award was presented to:

Thomas M. Holden, Research Scientist, *"In recognition of his innovative contributions, both key and wide-ranging, in advancing the technique for characterizing structural components by neutron diffraction and thereby establishing a materials evaluation facility unequalled in the world."*

The Newly Elected CNS Fellows for 1994

Each Fellow of the Canadian Nuclear Society is elected by the Society membership as a whole, and belongs to a special membership category denoting outstanding merit. The criteria for admission include *"major and sustained contributions to the sciences or professions that relate to the advancement of nuclear technology in Canada"*. Demonstrated maturity of judgement and breadth of experience, as well as outstanding technical capability and service to the Society are also requirements. In the tradition of honorary membership categories of learned societies, CNS Fellows are entitled to add the designation "F.C.N.S." to letters denoting degrees and professional certifications following their names.

Frederick C. Boyd, consultant, developer, administrator and advisor in nuclear energy and regulation, *"For his analytical contributions to the first CANDU nuclear energy plant, for his contributions to the inspired development and implementation of nuclear regulation in Canada and the world, and for his enthusiastic support of both branch and national programs of the Society and his creative editorship of the CNS Bulletin."*

Stanley R. Hatcher, research scientist, engineer, and leader and executive of many skills, *"For his many and varied scientific contributions to the advancement of reactor technology, for his numerous roles in the advancement of the CANDU business for the benefit of Canadians, and for his exemplary leadership as scientist, engineer and corporate executive."*

Daniel Rozon, nuclear engineering educator and researcher, and energy academician, *"For his extensive contributions to the development of the analysis of nuclear fission reactors, for excellence in his teaching, research direction and administration of academic institutes, and for his extensive involvement in nuclear affairs, particularly those under the auspices of the Canadian Nuclear Society."*

Prix et Honneurs 1994

La présentation des prix et honneurs a eu lieu le 7 juin 1994 au déjeuner de la SNC, conjointement avec le congrès annuel de la ANC et la SNC à Montréal. Les nominations de chaque catégorie de prix ou honneur sont indiquées ci-dessus.

Prix de l'Innovation, 1994

Ce prix a été établi par la Société Nucléaire Canadienne en 1991. Il récompense les réalisation innovatrices majeures dans la mise en oeuvre de nouveaux concepts dans le domaine du nucléaire au Canada. Le prix est sous la forme d'un trophée qui est une sculpture originale constituée de trois figurines supportant l'emblème de la SNC. Une version à échelle réduite est remis aux gagnants. Le gagnant 1994 est :

Thomas M. Holden, chercheur scientifique, *«en signe de reconnaissance pour avoir contribué de façon exceptionnelle, par ses travaux essentiels de grand envergure, à mettre au point la technique de caractérisation des éléments structurants par diffraction des neutrons, qui jouit maintenant d'une renommée mondiale pour son utilité industrielle.»*

Fellows de la Société Nucléaire Canadienne 1994

La Société a établi cette catégorie de membres en 1992 afin de reconnaître les contributions extraordinaires dans le domaine nucléaire. Les critéria d'admission encluent *des contributions majeures et soutenues aux sciences ou professions liées au progrès de la technologie nucléaire au Canada*. La maturité démontrée de jugement et les expériences professionelles, ainsi que les capabilités formidables technologiques et service à la Société sont pré-requis. Tout en suivant la tradition des sociétés des savants, les Fellows de la SNC ont le droit d'ajouter les lettres *F.S.N.C.* parmi celles indiquant leurs grades universitaires et certifications professionelles.

Frederick C. Boyd, consultant, promoteur, administrateur et conseiller en matière d'énergie nucléaire et de réglementation, *«pour avoir contribué par ses analyses à la création de la première centrale nucléaire CANDU, et pour avoir inspiré l'élaboration et la mise en oeuvre du processus de reglémentation nucléaire au Canada et dans le monde, et pour avoir soutenu avec enthousiasme les programmes des sections et les programmes nationaux de la SNC et, en particulier, pour la créativité dont il fait preuve à titre de rédacteur du Bulletin de la SNC».*

Stanley R. Hatcher, chercheur scientifique, ingénieur, meneur et dirigeant aux talents multiples, *«pour avoir énormément contribué à de nombreux titres à l'avancement de la technologie des réacteurs, pour avoir fait avancer le commerce CANDU au plus grand profit des Canadiens dans les nombreuses fonctions qu'il a occupées et pour avoir fait preuve d'un leadership exemplaire comme scientifique, ingénieur et chef d'entreprise.»*

Daniel Rozon, éducateur et chercheur en sciences nucléaires et universitaire de renom dans le secteur énergétique, *«pour sa grande contribution à la mise au point de l'analyse des réacteurs nucléaires de fission, pour l'excellence de son enseignement, de sa direction de recherches de son administration dans un établissement universitaire ainsi que pour son engagement soutenu dans le secteur nucléaire, en particulier sous les auspices de la Société nucléaire canadienne.»*

Fellows

Frederick C. Boyd, F.C.N.S.

Fred Boyd is one of the pioneers of the Canadian Nuclear Program. He has made important contributions to the evolution of nuclear applications, licensing and communications.

Fred Boyd is a native of Toronto, Ontario. In 1949 he obtained his B.A.Sc. in Engineering Physics from the University of Toronto, and has completed numerous courses in economics, philosophy, management and religion; this partially explains Fred's well known tendency for taking holistic approaches to the problem at hand.

Immediately following graduation, Fred worked first on radioisotope applications as a physicist/engineer with Eldorado Mining and Refining, and then on the first CANDU plant as a systems analyst with Canadian General Electric. In 1959 he joined the staff of the Atomic Energy Control Board (AECB) to become Head of Nuclear Facility Licensing and Executive Secretary of the Advisory Committee on Nuclear Safety. Working closely with George Laurence, Fred developed the Canadian Siting Guide, which became one of the foundation documents of nuclear power plant licensing in Canada, and a model for nuclear facility regulation in other countries as well.

From 1972 to 1978, Fred was nuclear energy advisor in the Department of Energy Mines and Resources (EMR). While on leave from EMR in 1978, Fred served as an International Atomic Energy Agency (IAEA) advisor to the Korean Ministry of Science and Technology, and then returned to the AECB as a senior advisor and Director of the Orientation Centre. Since his retirement from the AECB in 1989, Fred Boyd is a private consultant with Wild and Boyd Management Consultants Limited.

Fred Boyd is a long-time member of the Canadian Nuclear Society and has served in a variety of capacities both as a member of the CNS Council and on the Ottawa branch executive. As editor Fred has contributed much time and skill to making the CNS *Bulletin* an interesting, informative, topical and entertaining professional publication, for which all CNS members and other readers are grateful.

Stanley R. Hatcher, F.C.N.S.

Dr. Stanley Hatcher's career is a most distinguished one. He has made extensive scientific contributions in areas of reactor technology, heavy water production and waste management, all of which have been crucial to the advancement of nuclear technology in Canada. He is an exemplary leader in research and development and in the full range of executive responsibilities. He is also an effective champion of the CANDU program both at home and abroad.

Stan Hatcher was born near Salisbury, England and obtained his B.Sc. (1953) and M.Sc. (1954) degrees in Chemical Engineering from the University of Birmingham. In 1958 he obtained his Ph.D. in Chemical Engineering from the University of Toronto. On graduation Dr. Hatcher began his 34-year career with Atomic Energy of Canada Limited (AECL).

In Dr. Hatcher's early scientific research career with AECL, he made several important contributions to the understanding of the chemistry and to the design requirements of the primary coolant circuits of reactor concepts then under development, first at Chalk River and then at Whiteshell. In particular, he led a group that developed techniques to control fuel fouling and hydride formation in organic coolants subjected to the radiological, thermal and flow conditions of the WR-1 reactor that operated for many years at Whiteshell, and for the organic-cooled CANDU reactor concept that was advanced during the 1970's. In 1968-69 he served as AECL's liaison officer at the United Kingdom Atomic Energy Authority and in 1973-74 he led in optimizing the efficiency of the Bruce Heavy Water Plant as Head of the Process Technology Group.

In 1974 he was appointed Director of the Applied Science Division of Whiteshell and continued to focus on organic coolant problems while becoming increasingly involved with the Canadian Nuclear Fuel Waste Management Program of the thorium/uranium-233 fuel cycle in CANDU reactors.

From 1978 to 1992, Dr. Hatcher held a succession of key executive positions with AECL. These included Vice-President and General Manager of Whiteshell, Vice-President of Marketing and Sales at AECL CANDU in Mississauga and then President of AECL Research. On becoming President and Chief Executive Officer of Atomic Energy of Canada Limited, Dr. Hatcher played a key role in the successful presentation of the case for nuclear energy to the federal and provincial governments, thereby leading to the establishment of a period of stable funding for CANDU research and development and CANDU marketing activities.

Stan Hatcher has extensive professional involvements. He has served on Committees of the Pacific Nuclear Basin Nuclear Conferences of Vancouver, Seoul, Beijing and San Diego and is currently Vice-Chairman of this ongoing Conference. He has been a director of the Canadian Nuclear Association, the American Nuclear Society and the Council of Canadian Unity. He is a Fellow of the Canadian Academy of Engineering and the Chemical Institute of Canada, and a member of the Canadian Society for Chemical Engineering and the Professional Engineers of Ontario. As a charter member of the Canadian Nuclear Society, Stan has been a constant supporter of the Canadian Nuclear Society activities since its inception and, most recently, has devoted a great effort towards assisting both the CNA and the CNS in the area of enhancing public support of nuclear energy and nuclear technology in general.

Daniel Rozon, F.S.N.C.

Le professeur Daniel Rozon est un ingénieur en sciences nucléaires dont les contributions professionnelles au domaine de l'énergie nucléaire ont touché toute une gamme d'activités du milieu universitaire et de l'industrie, au Québec, au Canada et dans le monde entier.

M. Daniel Rozon est né à Lachute, au Québec. Il a tout d'abord fait des études classiques à l'Université de Montréal. En 1969, il a obtenu son diplôme en physique appliquée de l'École Polytechnique de Montréal, elle-même affilié à l'Université de Montréal. Il a été par la suite l'un des premiers à poursuivre ses études à l'Institut de génie nucléaire, le premier du genre au Canada, et à obtenir un diplôme. Après avoir passé un certain nombre d'années à l'emploi d'Hydro-Québec et d'EACL (à Mississauga), il a commencé à enseigner en sciences nucléaires à l'École Polytechnique où il est devenu professeur titulaire en 1990. Il a obtenu son doctorat en sciences nucléaires de l'Université McMaster, en 1985. Depuis 1988, le professeur Rozon est directeur de l'Institut de génie énergétique de l'École Polytechnique et titulaire de la chaire de génie nucléaire d'Hydro-Québec.

Les contributions de M. Rozon au domaine du nucléaire au Canada sont légion. Malheureusement, il ne nous sera pas possible de les mentionner toutes.

Pendant de nombreuses années, il a prodigué aux étudiants du deuxième cycle un enseignement de haute qualité notamment en cinétique des réacteurs, en gestion du combustible nucléaire et sur les aspects économiques de l'énergie nucléaire. Il a publié, en 1992, l'«Introduction à la cinétique des réacteurs», qui est le seul ouvrage sur la physique des réacteurs utilisant les réacteurs à eau lourde sous pression CANDU dans ses exemples chiffrés. Il a aussi donné la formation de base des chefs de quart et des premiers opérateurs de la centrale nucléaire Gentilly 2. Il a dirigé les thèses de maîtrise et de doctorat d'un grand nombre d'étudiants et il a aussi produit, seul et en collaboration, plus de 100 publications scientifiques et techniques.

Avec le regretté professeur Laurent Amyot, il a fondé le Groupe d'Analyse Nucléaire (GAN) qui visait le transfert technologique entre l'université et l'industrie grâce à l'appui d'Hydro-Québec et d'EACL. En 1988, le GAN est devenu un département de l'Institut de génie énergétique créé par le professeur Rozon.

Le professeur Rozon a présidé et co-présidé plusieurs conférences à l'échelle nationale et internationale. Nous pouvons souligner notamment le rôle important, qu'il joue depuis 1974 dans l'organisation du réputé «Symposium sur la simulation», qui est devenu, en 1980, le «Symposium annuel sur la simulation» de la SNC, nouvellement formée. Dans le même ordre d'idées, il a été le président du comité organisateur de la 2e Conférence internationale sur les méthodes de simulation en génie nucléaire, qui s'est tenue à Montréal, en 1983. M. Rozon a assumé d'importantes responsabilités dans l'organisation du Congrès de la Conférence mondiale de l'énergie.

Les avis et les conseils du professeur Rozon sont très sollicités dans nombre de domaines liés à l'industrie nucléaire. Il a notamment participé aux travaux du Comité consultatif de recherche et développement d'EACL; il a participé à la consultation publique sur le Plan de développement 1993 d'Hydro-Québec et a donné nombre de conférences générales sur l'énergie nucléaire.

M. Rozon est membre de la Société nucléaire canadienne depuis sa fondation; il a fait partie du conseil d'administration et a participé à un grand nombre d'autres conférences que celles que nous venons de mentionner.

Innovative Achievement Award

Thomas M. Holden — 1994

Introduction

Dr. Thomas Holden has spearheaded the use of neutron diffraction as a unique experimental probe to reveal strain and texture deep within structural materials. Under his leadership at the Chalk River Laboratories, the innovative utilization of neutrons has become accepted as a standard technique for characterizing structural components. This success has led to the formation of a group led by Dr. Holden and dedicated to Applied Neutron Diffraction for Industry (ANDI). The objectives are to apply and promote the novel use of neutrons as a non-destructive examination technique serving Canadian and international industrial clients. It is in recognition of Dr. Holden's key and wide-ranging contributions to the technical and operational success of ANDI that the Innovative Achievement Award is being presented in 1994.

Thomas M. Holden

Tom Holden hails from Ilkley, England. He received his B.Sc. in physics from the University of Leeds, and later received the Ph.D. degree from Leeds for his research on electronic structures in solids by low-temperature specific heat measurement. His career in neutron scattering research began during a two-year postdoctoral fellowship with G.E. Low at the U.K. Atomic Energy Authority, Harwell. Tom came to Chalk River Laboratories in 1966 as a postdoctoral fellow and became a permanent member of the scientific staff of Atomic Energy of Canada Limited (AECL) in 1967.

Tom's early interests focused on basic research into magnetic systems of matter in the solid state. Neutron scattering has been an essential tool of his research, and through his skill and diligence in scientific measurement, his many publications and his collaboration with others in the field, he has become a neutron scattering scientist of international stature.

In the early 1980s Tom became the principal scientist of a small group at Chalk River exploring the application of neutron scattering to industrial problems. Initial successes led to the formation of the ANDI group to develop contract business for AECL in support of Canadian industry. In 1986, Dr. Holden's initiatives were recognized through the Discovery Award by the President of AECL.

Dr. Holden's scientific activity continues at an impressive level. He has a total of 138 papers published in the open literature, and 35 ANDI reports. He has been Director of three Summer Schools on Neutron Scattering, given 17 invited talks on ANDI topics in the last three years, and presented a lecture

series and tutorials to the Instrument Society of America, the Brookhaven Summer School, the Euroconference on Thermal Neutrons, and at the International Summer School in Poland. He also served on the U.S. Basic Energy Sciences Advisory Committee on future neutron sources and chaired the Materials Science Subcommittee of the Workshop on Advanced Spallation Sources. He is the Canadian organizer of the first Workshop on Neutron Applications in Engineering and Materials Science, sponsored jointly by the Canadian Institute for Neutron Scattering and the Neutron Scattering Society of America, to be held at Chalk River in August 1994.

Innovative Achievement

Dr. Holden's innovative contributions to the success of ANDI are associated with its many phases of development. His contributions include identifying methods for inferring internal structures of materials from a basic understanding of the science of neutron scattering; forming and leading the ANDI team, and designing and acquiring the necessary instrumental facilities; identifying specific categories of feasible application and the promotion of the technique among client industries and national laboratories; organizing and directing the extensive parallel scholarly activities, including publications, lectures, conferences, workshops and exchanges, which have made the ANDI group a leader in the development and the practice of non-destructive examination by neutron diffraction.

Examples of applications include the now routine measurement of residual strain and texture in industrial components and investigation of multi-component systems such as composites or systems with minority phases. More recently developed techniques are those for the non-invasive measurement of temperatures in operating engines.

Applications in the nuclear industry itself include a standard quality assurance technique for examining the phase composition in LEU fuel, the assessment of strains at the grain intersections in pressure tube materials at various stages of the production process, and also the strains created in pressure tubes subjected to rolled-joint assembly as performed in power stations.

The international standing of the ANDI group and Dr. Holden's reputation for scientific excellence and leadership have attracted students and postdoctoral fellows from various technical centres of the world to train with the ANDI group.

Available

The following reports of general interest have been published recently:

Occupational Radiation Exposures in Canada, 1992

available from:

Communications Branch
Health Canada
Jeanne Mance Building, 19th floor
Ottawa, ON
K1A 0K9

AECB Annual Report 1993-94

available from:

Atomic Energy Control Board
280 Slater Street
P.O. Box 1046
Ottawa, ON

Bob Andrews (left foreground) and Aslam Lone (right back) explain the operation of cloud chambers to teacher participants of the 19th Science for Educators Seminar held at CRL April 1994.

Canadian Nuclear Society

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- ☐ OPERATION (to be formed)

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☐ INSTITUTIONAL	55.00

† New members joining after 1993 September 1st will be members for 1994. Fee includes GST.

If you are a non-member and attend an event on the 1993 or 1994 CNS Events Calendar, you are entitled to a $15.00 introductory discount on your first-year fees. Simply deduct $15.00 from your fees amount. _____
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- ☐ EXPLOITATION DES CENTRALES (à être formée)

TYPE D'ADHÉSION ET COTISATION POUR 1994†

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☐ RETRAITÉ(E)	30.00
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† Les membres qui enverront leur application après le 1er septembre 1993, seront automatiquement transférés à l'année 1994. Les frais de la TPS sont inclus dans les frais d'inscription.

Si vous ne faites pas parti des membres de la SNC et que vous vous êtes inscrit à l'un des événements au calendrier 1993 ou 1994 des activités de la SNC, vous avez alors droit à un rabais de 15.00 $ sur le montant de votre première cotisation. Veuillez simplement déduire 15.00 $ sur le montant. _____
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Téléphone (416) 977-7620

Calendar

1994

August 14-18 **SPECTRUM 94 International Nuclear and Hazardous Waste Management Conference**
Atlanta, Georgia
contact: John Steele
Westinghouse Savannah River
Aiken, SC, USA 29802
Tel.: 803-725-1830

September 12-16 **3rd International Symposium on Contribution of Materials Investigations to the Problems Encountered in Pressurized Water Reactors**
Fontrevaud (Chinon), France
contact: Ms. Christiane Moura
Société Française d'Energie Nucléaire
48 rue de la Procession
F75724 Paris Cedex 15, France

October 2-6 **ENC '94**
Lyon, France
contact: Dr. Peter Feuz
European Nuclear Society
Monbijoustrasse 5,
P.O. Box 5032
CH 3001, Berne, Switzerland
Fax: 41-31-22-9203

October 12-14 **Simulation Symposium**
Chalk River, Ontario
contact: Peter Laughton
AECL Research,
CRL Chalk River, Ont.
Fax: 613-584-1108

October 19-21 **3rd International Containment Conference**
Toronto, Ontario
contact: D. Pendergast
AECL-CANDU
Tel: 905-823-9040
Fax: 905-823-8006

November ??? **CANDU Safety Course**
Toronto, Ontario
contact: Lou Ferandes
OH Darlington
Tel: 905-623-6670 Ext. 7889

November 12-13 **2nd Workshop on Safety of Soviet-Designed Nuclear Power Plants**
Washington, DC
contact: Dr. David J. Diamond
Brookhaven National Laboratory
Upton, NY, USA
Fax: 516-282-5730
E.Mail – diamond@bnl.gov

November 13-17 **ANS Winter Meeting**
Washington, DC
contact: American Nuclear Society
La Grange, Illinois
Tel: 708-352-6611
Fax: 708-352-6464

1995

March ?? **CNA/CNS Student Conference**
Winnipeg, Manitoba
contact: Sylvie Caron
CNA/CNS office
Toronto, Ontario
Tel.: 416-977-6152 xt18
Fax: 416-979-8356

May 1-5 **CANDU Thermalhydraulics Course**
Hamilton, Ontario
contact: Prof. M. Shoukri
McMaster University
Hamilton, Ont.
Tel. 905-525-9140 Ext. 24881

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 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 **International Seminar on Heat and Mass Transfer in Severe Reactor Accidents**
Cesme, Turkey
contact: Dr. J.T. Rogers
Carleton University
Ottawa, Ontario
Tel: 613-788-5692
Fax: 613-788-5715

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 ??? **Workshop on Management and Operation of Nuclear Power Stations Using Digital Computers**
Fredericton, New Brunswick
contact: Roger McKenzie
Maritime Nuclear Ltd.
Fredericton, N.B.
FAX 506-453-1356

June 4-7 **CNA/CNS Annual Conference**
Saskatoon, Saskatchewan
contact: Sylvie Caron
CNA/CNS office
Toronto, Ontario
Tel.: 416-977-6152 xt18
Fax: 416-979-8356

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. Daniel E. Simpson
ANS Inc, Richland, WA
Tel.: 509-527-1665

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

September ?? **International Conference on Waste Management**
Manitoba
contact: C. Vandergraaf
AECL Research,
WL Pinawa, Manitoba
Tel. 204-753-2311 Ext. 2592.

October 1-4 **Fourth International Conference on CANDU Fuel**
Pembroke, ON
contact: Dr. Peter Boczar
Chalk River Laboratories
Tel.: 613-584-3311

November 20-21 **3rd Conference on CANDU Maintenance**
Toronto, ON
contact: Mr. Tim Andreef
Ontario Hydro
Tel.: 416-592-3217
Fax: 416-592-7111

Deadline

The deadline for the next issue of the *CNS Bulletin*,
Vol. 15, No. 3, Fall 1994,
will be 9 September 1994.

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1994-1995

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