CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

Summer / L'été 1990 Vol. 11, No. 2

IN THIS ISSUE:

- Licensing safety software
  - *a critical review of the process*
- Conference Reports
  - *the Steam Generator and Heat Exchanger Conference*
  - *the 1990 CNS Annual Conference*
- The AECB expansion
  - *a statement from the AECB president*
- Book reviews
  - *two interesting recent publications*

Contents

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ISSN 0714-7074

The *Bulletin of the Canadian Nuclear Society* is published by the Canadian Nuclear Society; 111 Elizabeth St., 11th Floor; Toronto, Ontario; Canada; M5G 1P7.
(Telephone (416) 977-7620; Telex 06-23741; Fax 979-8356).

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

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

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

Editor / *Rédacteur*
Fred Boyd (613) 592-2256

Our Higher Purpose

At the risk of immodesty, we might be tempted to claim that the CNS constitutes a grouping in society uniquely qualified to contribute to public discussion of matters nuclear. Our membership does, after all, possess a goodly fraction of Canada's nuclear expertise. In common with most other scientific societies in Canada, however, we are mostly mute. How often would it occur to a reporter to invite comment on a nuclear incident or event from a spokesperson from the CNS? Do any of them know we exist? Should they? And should we do anything about it?

The objectives of the CNS include "to foster the development and utilization of nuclear science and technology for peaceful purposes" and "to act as a forum for the exchange of information relating to nuclear science and technology." We should consider whether we have also a public duty, by virtue of the unique collection of talents which we represent, to participate proactively in public discussion of these subjects. If not us, then who? Canadian Nuclear Association? Pollution Probe? General Electric Canada? The Canadian Coalition for Nuclear Responsibility? Ontario Hydro? These organizations all speak (or claim to speak) on behalf of specific constituencies within society. Who speaks on behalf of the scientific community in Canada?

We are all of us hardened to tuning out the self serving bleatings of the various professional groups in society that claim to protect the "public interest". The public interest is, of course, usually defined as requiring the strict enforcement of "professional standards", typically by eliminating any vestiges of competition within the "profession", especially those based on price, and maintaining the barricades against competing groups (especially non-professionals). It also requires more and stronger doses of whatever medicine the professional group in question happens to be peddling. We have so far avoided the first trap. Can we also claim to be free from the second?

How credibly could a CNS spokesperson be perceived as an advocate of scientific and technical integrity and not of the career aspirations of our members? Only if we can provide commentary and advice which is not only accurate, but which also is independent. This may, on occasion, create difficulty for an individual responding to an issue which involves his or her employer. In these cases, the spokesperson would indicate a potential conflict of interest and refer the questioner to another member of the team.

We won't know unless we try. Let's have your suggestions. Any volunteers for a CNS Public Information Panel?

Keith Bradley

A Need for Dialogue

In his address to the CNA/CNS conference last year on the Ontario Nuclear Safety Review which he had just completed, Dr. Kenneth Hare commented that he had observed, during his studies, how insular and introvertic the nuclear community is. He expressed concern about this attitude and urged his listeners to expand their horizons and widen their contacts. Especially serious, he contended, was the lack of dialogue with other scientific and technical groups. The result, he noted, was that many, and possibly a majority of scientifically and technically trained people in the country know very little about nuclear issues and, as a consequence, often share the negative attitudes of much of the public.

A casual check of your colleagues will probably confirm Dr. Hare's observation. An example is the very small numbers of CNS members who are also members of the Canadian Radiation Protection Association despite the close association of topics covered.

This introvertic behaviour can be damaging. Not only do we miss the opportunity to enlist fellow scientific professionals in the on-going task of informing and convincing the general public of the benefits of nuclear energy we also forego a chance to expand our own perspective and knowledge.

Perhaps in the great challenge of modifying public opinion to be more aware of, and receptive to, things nuclear our first step is to open our eyes and ears to the world around us.

Appreciation

One of the many objectives of a technical professional society is to encourage and facilitate the exchange of knowledge. Within the CNS, as for many similar organizations, the primary mechanism is the symposium.

The CNS can be proud of its record in this area with a good example reflected in the pages of this issue in the excellent reports on the Steam Generator and Annual Conferences. For those of you who were not able to attend, or, if you did, were not able to at every session (a physical impossibility) these reports provide an overview and reflect some of the flavour of the papers presented at those meetings.

We are especially indebted to Ed Price, chairman of the successful Steam Generator and Heat Exchanger Conference in early May for the report on that conference and to Ben Rouben, co-chairman of the 1990 Annual Conference for compiling the reports on most of the sessions of that event. Of course, the individual session chairmen who provided the specific summaries deserve recognition and our thanks. It is through the efforts of members such as these that the CNS is as successful as it is. Hopefully many more will follow their example.

Our New President

Elsewhere in this issue you will find a message from our new president, Hugues Bonin.

Hugues brings many attributes to the position of chairman, both professional and personal.

He has three bachelor degrees, from Collège Saint-Laurent, Université de Montréal and École Polytechnique de Montréal; a masters degree in nuclear engineering from l'Institut de Génie Nucléaire de l'École Polytechnique and a Ph.D. in nuclear engineering from Purdue University.

Since 1979 he has been at the Royal Military College in Kingston where he is a professor of nuclear engineering.

Hugues is a charter member of the CNS and has been very active in the society as: chairman of the communications committee, associate editor of the *Bulletin*, chairman of the program committee, 2nd vice-president, and 1st vice-president. He is also a Fellow of the Chemical Institute of Canada.

Hugues brings an additional dimension to the position – he is the first CNS president whose mother tongue is French.

Il me fait plaisir de travailler avec notre nouveau président.

Fred Boyd

Letter to the Editor

Mistaken Mamba

Dear Sir:

Re *Mamba's U.S. Excursion* . . . George (*The Unfashionable Side*) Bauer is mistaken in believing that Mamba Wildfang had been repulsed by American thermalhydraulicists of the ANS. It is my understanding that Mamba, being "most the proficient nuclear critic ever", exhibits the nuclear critics' finest attribute to the highest degree. She has a fine incapacity for reaching a logical conclusion. Thus, in reaching "Hillside" she wandered around for a few months fanging a few public information officers without ever finding Hinsdale, where the ANS might have been located. Thus, while exploring the Western Chicagoan suburbs she was never put to the task of discovering that the ANS left Hinsdale many years ago and has been relocated in La Grange Park for at least a decade. It was only after Mamba had a nasty experience in confusing a sanitary officer for a thermalhydraulicist that she returned to the Canadian Chicago-look-alike which adheres like plaque to the arterial 401. It was there, driving along in her Morris Minor, watching some of the more colorful denizens of Ontario's ghetto, that she discovered the ninth basic thermalhydraulic element: drag.

John Graham

(not from Washington, D.C.)

Board of Directors, A.N.S.

(*Ed. Note – Correspondent John Graham is with AECL Research Company in Ottawa.)*

1991 CNS Simulation Symposium – Call for Papers

Sponsored by the Nuclear Science and Engineering Division of the CNS and hosted by New Brunswick Power, the 16th Annual Nuclear Simulation Symposium will be held on August 26 and 27, 1991 at the Delta Hotel in Saint John, New Brunswick.

The scope of the Symposium covers all aspects of nuclear modelling and simulation, and usually includes sessions on system simulation, thermalhydraulics, reactor physics, and related aspects of R&D and safety analysis. The main objective of the Symposium is to provide a forum for stimulating discussions and exchange of views amongst engineers and scientists working in the Canadian Nuclear Industry. Presenting a paper at this Symposium does not preclude presentation elsewhere and papers are encouraged on unresolved problems and/or methods under development. Full papers are usually 10 or 20 pages long but shorter papers (and short presentations) are quite acceptable.

The deadline for receipt of your abstract of 300 words or less is January 31, 1991. This should be sent for review to:

P.D. Thompson
NB Power
Point Lepreau Generating Station
P.O. Box 10
Lepreau, New Brunswick
E0G 2H0

Authors will be notified of paper acceptance by April 1991. The deadline for receipt of the final full paper will be July 1, 1991.

For further information call Paul Thompson at (506) 659-2220 ext 234 or FAX (506) 659-2703.

Message du Président

Atteindre la maturité

Hugues W. Bonin

Devenir Président de la Société Nucléaire Canadienne représente pour moi un grand honneur, un défi et un plaisir. En particulier, le fait d'avoir élu pour la première fois un Président francophone constitue un événement significatif pour la Société qui, je le souhaite, incitera mes collègues francophones à s'impliquer davantage dans les affaires de la S.N.C.

Je tiens d'abord à vous remercier de l'honneur et de la confiance que vous me faites, et à exprimer ma gratitude à Mme Eva Rosinger, au Conseil, aux Officiers et aux membres de la S.N.C. pour leurs efforts qui ont permis à la Société de connaître une année des plus fructueuses.

Grâce aux efforts soutenus des anciens présidents et des officiers de la S.N.C., celle-ci s'est développée au cours des onze années de son existence au point d'atteindre une maturité reconnue à l'échelle mondiale. Non seulement les autres sociétés savantes n'hésitent guère à accorder leur commandite aux conférences organisées par la S.N.C. lorsque l'on en fait la demande, mais elles sollicitent la commandite de la S.N.C. pour leurs propres conférences de plus en plus souvent. De plus, la S.N.C. est à établir des liens priviligiés avec les autres pays à un rythme croissant, et nous espérons signer documents d'entente avec deux autres sociétés nucléaires dans les mois qui viennent.

La maturité de notre Société se manifeste aussi au niveau du programme de conférences, qui, grâce aux efforts des comités des Divisions Techniques et de toutes les personnes qui ont oeuvré et qui travaillent au sein des comités organisateurs, permet à la S.N.C. d'offrir une panoplie de conférences et de symposia, et même de cours de développement professionnel, dans une gamme de domaines qui intéressent nos membres. La participation étrangère à nos conférences se fait de plus en plus importante, et atteste de leur très haute qualité technique.

Atteindre la maturité ne signifie pas s'asseoir sur ses lauriers. Il y a encore beaucoup à faire. Grâce au travail de M. Troy Lassau, le nombre de membres a augmenté pour dépasser les 700. Cependant, considérant qu'il y a au Canada plus de 5 000 personnes associées au domaine du nucléaire, la S.N.C. a tout à gagner en contactant ces gens et en les persuadant de "tenter l'aventure" d'adhérer à la S.N.C. Pour cela, la Société doit continuer d'augmenter les services à ses membres: conférences, cours, séminars, activité locales, . . .

Une des priorités de ce mandat est de remettre le Comité des Communications en action. Au cours des années passées, beaucoup d'énergies ont été consacrées au Bulletin de la S.N.C. et au "Canadian Nuclear Journal", de sorte que plusieurs projets de ce Comité ont d être laissés en suspens. La structure envisagée pour ce Comité est d'en faire un Comité conjoint avec le Comité de l'Éducation et des Ressources Humaines de l'Association Nucléaire Canadienne. Mon expérience personnelle m'a permis de constater un chevauchement d'activités important entre les deux comités, et une fusion permettra d'éviter une duplication des efforts. Le premier projet du nouveau Comité A.N.C. – S.N.C. des Communications et des Ressources Humaines sera celui de créer une brochure sur les carrières en science et en génie nucléaires. Le besoin d'une telle brochure est immense, alors que l'industrie nucléaire canadienne s'apprête à rencontrer les défis des années 90. Le recrutement de jeunes scientifiques et ingénieurs se fait de plus en plus difficile pour l'industrie, et l'existence de certains programmes univeritaires de génie nucléaire est même remise en question, faute d'étudiants en nombre suffisant. Le but d'une telle brochure est de dire aux jeunes qu'il y a de l'avenir dans le nucléaire, contrairement à ce que laisse croire le presse à sensation.

Il est essentiel de maintenir la vitalité de nos sections locales. La plupart offrent maintenant des programmes intéressantes d'activités diverses et ceci devrait continuer. Ce sont les activités des sections locales qui permettent les meilleurs échanges entre les membres non seulement sur le plan technique, mais aussi sur plan personnel et social.

Notre "Bulletin de la S.N.C." est présentement entre bonnes mains, et son nouveau rédacteur, M. Fred Boyd, est déterminé à en faire une publication régulière et d'une lecture agréable pour tous. Cependant, il s'attend à être épaulé dans sa tâche par les membres da la S.N.C. Il se peut que vous trouviez mes propos un peu forts ici, mais je conçois comme un devoir pour tout membre de la S.N.C. de contribuer, ne serait-ce que modestement, au Bulletin. Vous avez certes quelque opinion à partager ou quelque nouvelle à faire savoir: votre équipe de recherche vient de faire une nouvelle trouvaille, vous venez d'avoir une promotion, votre collègue a changé d'emploi: faites-nous le savoir en communiquant avec Fred! Ici, je m'adresse particulièrement aux Francophones: la Société Nucléaire Canadienne est bilingue, et vient de le réaffirmer en élisant son premier président francophone. N'hésitez pas à contribuer au Bulletin en Français! Il serait regrettable que les francophones se sentent laissés de côté, et je considère comme un service à rendre à nos collègues anglophones qui apprennent présentement le français que de les exposer régulièrement à la langue de Molière via notre Bulletin.

Bien d'autres projets seront discutés par le Conseil de la S.N.C. et ses Officiers en 90-91. Nous comptons sur vous tous et toutes pour vos suggestions et commentaires, et surtout, nous comptons sur vous pour vous porter volontaires pour des missions modestes, comme la participation à un comité ou à l'organisation de conférences, ou encore, votre contribution personnelle au recrutement de quelques nouveaux membres. Je ne crois pas qu'une Société soit saine si seulement un petit groupe d'individus sont actifs et doivent se charger de tâches qui dépassent leurs temps libres. Tôt au tard, l'ampleur de la tâche dépasse les ressources disponibles forçant à l'abandon de projets

importants, ce qui mène au désappointement des membres. Je voudrais plutôt préconiser la situation où un grand nombre de membres s'impliquent dans les activités de la S.N.C., chacun se portant volontaire pour un projet ne demandent qu'une contribution modeste en temps et en effort. Les chances de succès n'en seront que meilleures, et la somme de tous les succès ainsi obtenus fera en sorte que la Société sera prospère dans un climat positif.

Je vous remercie de la confiance que vous me portez, ainsi que de celle que vous accordez au nouveau Conseil et Officiers de la S.N.C. Soyez assurés que nous ferons de notre mieux pour vous servir et nous comptons sur votre encouragement, vos commentaires et suggestions.

Hugues W. Bonin
Président

Message from the President

Reaching maturity

Becoming President of the Canadian Nuclear Society represents for me a great honour, a challenge and a pleasure. In particular, the fact of having elected for the first time a Francophone President is a significant event for the Society and, I hope, this will induce my French-speaking colleagues to become more involved in the affairs of the C.N.S.

Firstly, I want to thank you for the honour and the confidence you give me, and to express my gratitude to Dr. Eva Rosinger, the Council, the Officers and the members of the C.N.S. for their work which has provided the C.N.S. with yet another fruitful year.

Thanks to the sustained efforts of the past Presidents and Officers of the C.N.S., our Society has developed during the eleven years of its existence to reach a maturity now recognized throughout the world. Not only do the other learned Societies not hesitate to co-sponsor C.N.S.-organized conferences when asked, but they request more and more often the C.N.S. cosponsorship of their own conferences. In addition, the Canadian Nuclear Society is establishing privileged links with other countries with increasing frequency. We hope to sign documents of cooperation with two more nuclear Societies in the coming months.

The maturity of the C.N.S. is also evidenced at the conference program which, thanks to the work of the Technical Divisions Committees and of all the persons who collaborated or are still working on conference organizing Committees, enables the C.N.S. to offer a panoply of conferences and symposia, even short courses, in a variety of domains of interest to our members. More and more foreign participants register at our conferences, thus demonstrating the high technical quality of our meetings.

Reaching maturity does not mean resting on our laurels. There is much to do. Mr. Troy Lassau's excellent work on the Membership Committee has resulted in our membership exceeding the 700-mark. However, considering that there are in Canada more than 5,000 persons associated with nuclear science and engineering, the C.N.S. can only succeed further by contacting these persons and convincing them to join our Society. For this purpose, the C.N.S. must continue to emphasize services to its membership: *viz* conferences, short courses, seminars, local activities, etc . . .

One of my priorities is to put our Communications Committee back into action. During the past years, a lot of energy has been spent on the C.N.S. Bulletin and the Canadian Nuclear Journal, leaving several other projects of this Committee on hold. The proposed structure is a joint Committee with the Canadian Nuclear Association Education and Human Resources Committee. My personal experience on both committees has shown me a considerable overlapping of the activities, and a fusion should avoid this duplication. The first project for the new C.N.S. – C.N.A. Communications and Human Resources Committee will be to create a booklet on careers in nuclear science and engineering. The need for such a brochure is acute at the moment when the Canadian nuclear industry is getting ready to face the challenges of the 90's. The recruitment of young scientists and engineers is more and more difficult for the nuclear industry, and in addition because of low student enrolment, the existence of some university programs in nuclear engineering is questioned. The purpose of such a booklet is to tell the young generation that there is indeed a future for them within the nuclear industry, contrary to what the sensationalistic mass media make believe.

It is most important to maintain the vitality of our local Branches. Now, most offer interesting programs of various activities, and this should continue. It is these activities that enable the best exchanges between the C.N.S. members, not only on the technical point of view, but also on the individual and social aspects.

Our C.N.S. Bulletin is presently in good hands, and the new editor, Mr. Fred Boyd, is determined to make it a regular and pleasing publication. He expects to be supported in this task by the members of the C.N.S. It is possible that you will find my point of view rather strong here, but I see it as a duty for all members of the C.N.S. to contribute to the Bulletin, however modestly. You have certainly some opinions or news items to share with others: *e.g.* your research team has just made some new findings, you have recently been promoted, a colleague of yours has started on a new job, . . .: tell us by contacting Fred! At this point, I'm speaking to the Francophones in particular: the C.N.S. is a bilingual Society, and has just confirmed this nature by electing its first Francophone President. Do not hesitate to contribute to the Bulletin in French! It would be a pity

that the Francophones feel that they are left aside, and I consider as a service to give to our Anglophone colleagues who are learning French the regular exposure to Molière's language via our Bulletin.

Many more projects will be discussed by the C.N.S. Council and its Officers in 90-91. We count on you all for your suggestions and comments. Mostly we rely on you as volunteers for modest tasks, such as serving on a committee or helping to organize a conference, or even, your personal effort toward the recruitment of new members. I do not believe a Society is healthy if only a small group of individuals is active. Sooner or later, the magnitude of their tasks will exceed their available time resources and will lead to the abandonment of projects, resulting in the disenchantment of the members.

I would rather advocate the situation where a large number of members actively contribute to the C.N.S., each one volunteering for a small project demanding little time and effort involved. The chances for success would therefore be greater, and the sum of a large number of such successes will make our Society prosperous in a positive climate.

I thank all of you for the confidence you have put in me, and in our new Council and our new Officers. You may be assured that we will do our best to serve you, and we rely on your support, comments and suggestions.

Hugues W. Bonin
President

Special Report

Licensing Safety Critical Software

G.H. Archinoff and R.A. Brown, Ontario Hydro

1.0 Introduction

Licensing difficulties with the shutdown system software at the Darlington Nuclear Generating Station contributed to delays in starting up the station. Even though the station has now been given approval by the Atomic Energy Control Board (AECB) to operate, the software issue has not disappeared – Ontario Hydro has been instructed by the AECB to redesign the software. This article attempts to explain why software based shutdown systems were chosen for Darlington, why there was so much difficulty licensing them, and what the implications are for other safety related software based applications.

2.0 Software in Nuclear Safety Applications

In the early 1980s, when the decision was made to adopt software based shutdown systems, computer based systems held out the promise of several advantages over conventional systems. The major perceived advantages included: lower cost; increased flexibility to make late changes; better and more flexible displays of information for the operator; the ability to monitor the computer and hardware devices connected to it, and to turn failures of these devices into safe failures, thereby increasing the reliability of the system; and the ability to implement more complex trip parameters which could lead to increased operating margins.

The Darlington shutdown systems are not the only safety related application of computers in CANDU generating stations. Microprocessors implement the logic for the powerhouse emergency venting system and the shutdown system dump arrest unit at Pickering NGS A, as well as the heat transport pump trip logic at Bruce NGS A. Programmable logic controllers implement a portion of the shutdown system logic in the CANDU 600 MWe reactors. In addition, future applications of computer based technology in safety related functions are under consideration. These include digital trip meters as replacements for analog devices at Pickering NGS, and computers to perform the display and/or test functions for the proposed shutdown system modifications at Pickering NGS A. Decisions have yet to be made on the extent to which computers will play a role in the safety systems of the CANDU 3 reactor being designed by AECL CANDU, or the CANDU A plant under consideration by Ontario Hydro.

Computers also play a role in controlling key plant process systems, such as the reactor regulating system and the fuel handling system. Certain types of failures of these systems, caused by computer software failure or by other faults, can potentially lead to a radioactive release within the station or to severe equipment damage leading to significant economic consequences.

It is clear, therefore, that the use of computer technology to perform important safety or safety support functions is becoming more widespread, and that while computers can and do offer significant advantages, they also have the potential to cause significant damage if the software is not designed properly. The implication is that the design of software should be performed with at least the same care and rigour as any other design step in an engineered system. The unique feature of software, however, is that each new software application must be considered to be a brand new design, and should be thought of in the same way as a new design of an electronic component, or a new piping alloy, or a new structural material. We would

not think of using any of these latter examples without extensive testing and validation, and we would want them to meet strict standards. The same should be true of custom software. Changes to qualified software must also be treated carefully, because even a small change can cause a very significant difference in the behaviour of the controlled system.

A particular problem with qualifying software for safety critical applications is the lack of agreed upon standards for determining the adequacy of software. This, along with some specific problems discussed below, was one of the key difficulties which contributed to the problems licensing the Darlington shutdown system software.

3.0 Licensing the Darlington Shutdown System Software

There is a lengthy history associated with the Darlington shutdown systems. Ontario Hydro and AECL conducted a development program in the late 1970s aimed at assessing the feasibility of a computer based shutdown system and determining an appropriate system architecture. The AECB participated in this program. On the basis of this program, and the perceived advantages of a computer based system discussed earlier, the decision to implement computer based shutdown systems was made in 1982. Work on the system proceeded at AECL CANDU until 1987, when the AECB identified the shutdown system software as a potential licensing impediment because at that time, they concluded that the documentation of the software did not fully describe the design. Given that there were inconsistencies between the documentation and the code, the AECB staff concluded that it was not possible to determine if the code would meet its requirements. Furthermore, they were concerned that the software development plan, the adopted standard for the shutdown system software project, was not always being followed. There ensued considerable correspondence between Ontario Hydro and the AECB, with Ontario Hydro assuring the AECB that documentation inconsistencies notwithstanding, the software would perform its functions adequately.

The AECB then hired an external consultant, a recognized expert in software engineering whose current specialties include the use of software in safety critical applications. The consultant not only concurred with the AECB staff's position, he also identified specific actions which should be taken to increase the likelihood of producing acceptable software. These steps included redesigning the software using "information hiding" principles, periodically reinitializing as much of the software as possible to increase its reliability, redocumenting the software requirements using a formal notation and redocumenting the software design description, introducing an on-line documentation system, and performing random testing of the software.

Information hiding is an approach to structuring the software in a manner which facilitates changes after the software has been placed into service. The proposal to use this technique was not accepted by Ontario Hydro, on the basis that the chosen design, namely, mimicking the Bruce NGS B hardware design using software, was a sound approach. The Bruce NGS B design was proven and understood, and therefore emulating it via software represented an evolutionary development, which was considered by Ontario Hydro to be an appropriate choice for a special safety system.

The other major recommendations, namely, redocumentation of the software requirements and design description, and random testing, were accepted and implemented. On-line documentation systems will be implemented for future versions of the software.

It is the view of some of those involved that the decision not to redesign the software using information hiding principles was the key factor leading to delays in acceptance of the software. It has been postulated that had Ontario Hydro chosen to adopt the information hiding approach, many of the subsequent licensing problems would not have occurred. The authors disagree with this conclusion. The major activities which delayed acceptance of the software were incorporation of Ontario Hydro's own recommendations following a quality engineering review of the software and the software development process, and the formal verification exercise, about which more will be said later. Much of the delay resulting from the quality engineering review was independent of the approach to software design, and would have occurred even if an information hiding approach had been adopted. The formal verification idea was suggested by the AECB consultant as a mechanism for resolving what was at the time a licensing impasse – by early 1989 Ontario Hydro's position was that the software was adequate to perform its function, while the AECB's position was that the entire software documentation package was not retrievable and therefore regulatory approval could not be given. The consultant suggested that a "walkthrough" of the software would be a useful mechanism for the AECB to review the software and for Ontario Hydro to demonstrate the adequacy of the software.

What sounded like a practical solution turned out to be much more difficult than expected to implement. The first hurdle to be overcome was reaching agreement on the scope of the walkthrough, or guided inspection as it came to be known. It was eventually agreed that what was needed was a mathematical demonstration that the code met its requirements. The problem was that there was no method available for conducting such an exercise. Eventually, a method was developed by Ontario Hydro staff, based on ideas suggested by the consultant, and the SDS1 and SDS2 walkthroughs were conducted in the summer and fall of 1989, respectively. These were very intense, lengthy exercises, which severely strained the resources of both Ontario Hydro and the AECB. The process is described in detail in Reference 1. The software was found to be acceptable for use in the sense that it was shown to perform its safety functions correctly, but the AECB were concerned that the stage of the documentation and the software design was such that errors could be introduced when future changes were made. They did not feel that future guided inspections could be conducted with the same rigour as the first ones (one each for SDS1 and SDS2), and therefore requested that the software be redesigned so that regulatory approval could be given in the normal manner, without having to resort to such extreme measures.

The acceptance of the software was ultimately based on a mathematical demonstration of its correctness. It is the authors' view that if it was deemed necessary by the AECB for Ontario Hydro to provide such a demonstration, it would have been required regardless of whether or not the software design fol-

lowed information hiding principles. Therefore, some form of guided inspection *may* have made the process easier, but it would not have eliminated the need to undertake the exercise.

The foregoing discussion enumerates the many unexpected detours and sidetrips taken along the road to licensing the Darlington shutdown system software, and appears to indicate that licensing safety critical software is an unpredictable and therefore uncontrollable process. The question of whether or not this is a fundamental attribute of software for safety critical applications is addressed in the next section.

4.0 Lessons learned and what's being done about them

Considering the cost and effort expended to license the Darlington shutdown system software, there are several lessons to be learned. One conclusion might be to avoid software in any safety critical application. It would be unfortunate if this were the conclusion drawn, because it would preclude the future use of a technology which is rapidly becoming more widespread and accepted, and which could indeed offer significant advantages. On the other hand, we should not be so committed with computer technologies that we proceed blindly with them when we have not solved the key problems which gave rise to the difficulties in Darlington. We must make a balanced assessment of the available technologies, and consider fully the implications of operating the system in question for the full life of the plant. At the present time, however, the deck is stacked against software based technologies for new safety-related applications, unless we can resolve the issues which caused the difficulties with the Darlington software.

One of the key lessons learned is that there must be an agreed upon standard for software engineering. The lack of such a standard made it impossible for the software designers to show that the software design was adequate, and led the regulator to impose new standards and requirements during the design process. The need for such a standard has also been recognized by the AECB, and in fact they have confirmed that the redesign of the Darlington shutdown system software should not commence until a suitable standard has been developed. Work is underway at Ontario Hydro, AECL CANDU and the AECB to develop a standard for software engineering which would be applicable to safety critical software. Close communication between all three parties will be required if agreement on a standard is to be reached within a reasonable timeframe.

Even when a standard is agreed upon, there must be rigorous adherence to it. One of the lessons learned from Darlington is that deviation from the planned software development process is a prescription for failure. SQA (*s*oftware *q*uality *a*ssurance) must be more than a buzzword.

Another important lesson pertains to the AECB. From the licensee's perspective, it was felt that AECB staff played too great a role in trying to influence the design of the software, which complicated Ontario Hydro's decision-making process with respect to providing a rational and acceptable design. In future, stricter adherence to the traditional regulator/licensee roles will be necessary to achieve an acceptable licensing process. Agreement on standards should go a long way to resolving this problem.

The final, and perhaps the most important lesson, is a recurring one, namely, that changes to the licensing groundrules during the design process must be avoided. We have seen numerous licensing requirements imposed during the Darlington shutdown system software design process. In each case, the additional requirement was justified by the AECB as being necessary for them to rule favourably on the adequacy of the software. Agreement on standards will go a long way towards avoiding imposition of new requirements during the design process, but given the rapidly advancing state of the art of software engineering, there will always be a temptation to ratchet the requirements to catch up with the latest techniques. This not only makes the design process impractical, it may also be dangerous. Safety critical systems should be based on proven design methods, not on the latest bright but unproven ideas proposed by experts in the field.

It is common and prudent practice in the nuclear industry to evaluate the lessons learned at one plant and to assess the implications for other plants. In the case of safety critical software, there are no other CANDU plants whose special safety systems employ software to the degree that the Darlington shutdown systems do. Software is pervasive, however, particularly in important process systems and in some safety related applications, as discussed earlier, and there will clearly be some impact on the operating plants. What must not be forgotten is that for the most part, computer based systems at the operating plants have been operating successfully for many years. A successful operating history is perhaps the best evidence of correct software, and this fact has been recognized by the AECB (Reference 2). Care must be taken, however, that modifications to the software do not invalidate the successful operating history to the extent that the entire software package can be questioned. The standard for software engineering presently under development will deal with configuration management, and it may be that applying at least this portion of the standard to existing software will preclude the need for more extensive and costly evaluations of existing software.

5.0 Conclusions

Some of the benefits expected from the computer based shutdown systems at Darlington have been realized, but many have not, including the key ones of reduced cost and increased flexibility. This article has attempted to deal with the issue of whether there is something fundamental about software which makes its use inappropriate for safety critical applications, or whether the problems licensing Darlington can be overcome in future applications. Our conclusion is that the problems can be overcome, but we are not there yet.

We must get on with the job of solving the problems which gave rise to the difficulties licensing Darlington, and we are doing so. Software is too pervasive to turn the clock back now to fully hardware based systems, and our options for using hardware based systems for future plants are likely to diminish with time. Once we have resolved the major problems, we will once again be in a position to consider the use of software in new safety critical applications for major plant systems.

One of the particularly difficult issues is that of software change control. Flexibility to make changes is one of the most attractive features of software based systems. At the present

time, however, making even a small change to safety critical software involves such extensive modifications to documentation and licensing effort, that this important benefit of software has turned into a serious liability. Unless this problem is overcome, software based systems for safety critical applications will not gain acceptance by plant operators. There are ways to deal with this problem, but we will have to go right back to the earliest design stages and recognize that rapid turnaround for simple changes is an important design requirement.

The lessons learned in the licensing of the Darlington shutdown system software are being acted upon. Only time will tell if the solutions to the problems are sufficiently effective that software based systems for safety critical applications can once again be serious contenders for use. It is possible that the benefits offered by software will just not be worth the effort to design and license it for safety critical applications. It would be premature, however, to come to this conclusion now, before we have had a chance to develop and judge the effectiveness of the solutions. It would also be unfortunate if software based systems were rejected out of hand, because to do so would foreclose an option with ever increasing features and abilities.

References

1. G.H. Archinoff, et al, "Verification of the Shutdown System Software at the Darlington Nuclear Generating Station," Int'l. Conf. on Control and Instrumentation in Nuclear Installations, May 8-10, 1990, Glasgow, United Kingdom.
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Ed. Note: Senior AECB officials were offered an opportunity to comment on the above article but declined to do so. The official AECB staff report on Darlington (early 1989) noted inadequacies of: software documentation, validation, and testing.

Viewpoint

Public Opinion and the Full Power of the Mind

Hans Y. Tammemagi

Although it is often stated that the subconscious mind is more powerful than the conscious one, it wasn't until recently, while dozing at the annual CNA plenary session, that I began to be convinced. As speaker after speaker droned on, reiterating the importance of public opinion, my head nodded and I began to unleash the full potential of my mind.

Making the public love nuclear power is a herculean undertaking, as witnessed by the limited progress made over the past decade, in spite of lavish budgets expended by AECL, Ontario Hydro and the CNA. Unfortunately, the present strategy ensures that we are destined to fighting a battle in which the war can not be won. The antinuclear forces are fighting a guerilla war; they do not play by the conventional rules and use every conceivable tactic to gain empathy with the public. Their cause is made easier as the public loves to hate the big corporation and loves to cheer for the underdog, the small environmental watchdog. Amazingly, the big boys (AECL and Hydro) play right into their hands by continually extolling the big corporate image.

As slide after slide clicked away my sleep (and power of analysis) grew deeper. The solution, or at least part of it, I realized, is to bring the battle to the people. Like the guerrillas, we need to get amongst the people and build popular support. But how?

As my head slid to one side and came to rest on the shoulder of the co-conferee to my right I realized that the most intimate and personal aspect of nuclear power is medical applications. Instead of dwelling endlessly on megalithic nuclear power plants and how inherently safe and cheap they are, we should change tack and focus on more personal aspects such as nuclear medicine. Interestingly, the CNA booth in the Exhibition Hall featured 18 fact sheets, of which only one dealt with nuclear medicine. People do not associate with robotic fuelling machines, or a vacuum building consisting of umpteen tonnes of concrete.

However, there is nothing more personal than our health. Virtually all of us either have been, or know someone who has been, treated at a hospital by nuclear techniques such as gamma scans, cobalt therapy or other radiological methods. These are seen as good processes which improve our quality of life, lengthen our life spans and with which we can definitely associate. Even antinukes can't challenge the benefits of better health, (although I am sure they would try).

As my neighbour's elbow burrowed into my side in a futile attempt to lessen my muffled snoring, the importance of disassociating nuclear from the big corporate image and instead emphasizing its personal aspects grew clearer. In addition to changing the message we need to change the messenger. Instead of counting sheep, an endless line of faceless AECL speakers began to drift across my field of view, all of them using the same slide set and bringing the same message. I narrowly averted screaming out as the nightmare began to unfold. However, the plenary session rolled on undisturbed as a more soothing image replaced the hordes of speakers. The solution is to create a comprehensive network of public speakers which would be drawn from the entire cross section of the nuclear industry including teachers and, best of all, medical people. The intent would be to provide a knowledgeable local person

when an organization requests a speaker instead of an AECL or Hydro person sent from a distance at great expense and bringing a 'canned' and impersonal corporate message. The impact of someone that is from the area will be much greater than the stranger who delivers the vanilla talk and toes the party line. The 'neighbour' would deliver in his own words how he/she feels about nuclear and why. The talks would also be more interesting because the speakers will bring different perspectives as well as the nuclear medicine theme.

This is not an original idea and may not be easy to implement. The concept of a speakers bureau was tried by the CNA but never got off the ground. I'm not surprised, as it would be logistically difficult to organize and probably would be perceived as a threat by the AECL/Hydro corporate public affairs empires on the one hand and by their corporate management on the other. (Heavens, they might not wear a tie and their talk hasn't been approved by at least five layers of management.) With both hemispheres in full operation, it was clear that these are rationalizations; in fact, there would be considerable coordination required and information kits and slides would be needed from which the speakers could draw. I started to draw up plans . . .

But suddenly I was jolted out of my reverie by loud applause. (They liked my idea!) I stumbled to my feet to take a bow, with some difficulty as my leg had fallen asleep. Slowly realizing that the applause was in response to the session chairman's call for coffee break, I limped out, massaging my sore neck.

Conference Report

Steam Generator and Heat Exchanger Conference

May 1990

Ed Price

Ed Price, Conference Chairman

The Canadian Nuclear Society, together with co-sponsors the CANDU Owners' Group and the American Nuclear Society, held a very successful conference on Steam Generators and Heat Exchangers early in May in Toronto. In contrast with many symposia and seminars on related subjects, this conference encouraged papers in a wide range of technologies that impact on steam generator design, construction and operation. In addition, papers that reviewed the performance of other major heat exchangers were sought; unfortunately, however, only the Canadian participants responded with papers on these components even though they pose significant maintenance problems for many PWR's as well as CANDU's.

While steam generator maintenance and rehabilitation have been a problem in many PWR stations for a number of years, the Canadian steam generator performance, for many reasons, has been extremely good. In recent years, however, the large financial involvement of many PWR utilities and vendors has resulted in improved steam generator performance. The conference enabled a comparison of Canadian and PWR practice in a number of the associated technologies and ensured that a good overview of the steam generator technology was obtained by the participants. This was helped by the presentation in each session of excellent invited overview papers which provided both the PWR view and the corresponding Canadian view.

The conference was divided into seven technical sessions and one poster session. The technical sessions covered operational performance, steam generator chemistry control, inspection, design, materials and thermalhydraulics and two sessions on research and development.

In the opening session on general operating experience, J.C. Blomgren of Commonwealth Edison provided the conference with an overview of the current performance of steam generators and showed how problems caused 16 billion kilowatt-hours of lost electricity generation world-wide in 1988. The known problems associated with tube degradation and moisture separation difficulties are now joined by shell degradation concerns. There has been an increasing number of tubes plugged per unit since 1980 but the average number of tubes plugged per unit is still only about 0.25% per year. The likely result will be increased numbers of steam generator replacements. There are, however, encouraging signs that improved understanding of design, operating characteristics and fundamentals of materials of fabrication are leading to increased reliability and performance. P. Spekkens of Ontario Hydro reviewed the CANDU performance which to date has been excellent. Fouling of tube support plates on some units, general tube fouling leading to higher reactor inlet temperatures, and accumulations of tube sheet sludge are all concerns which are currently being addressed.

A significant exception to the poor performance of PWR steam generators has been the experience of steam generators in KWU/Siemens plants as outlined by R. Bouecke. The number of plugged tubes has reached low levels in recent years and plugging has only been the result of tube wastage due to the use of phosphate chemistry which continues in only three plants.

Replacement of steam generators in existing plants is not anticipated. Siemens/KWU, CANDU 6 and Darlington use Incoloy 800 as the tubing material.

In the chemistry control session Peter Paine of EPRI gave the PWR overview describing the industry's response to various forms of degradation with redesign, back fitting and strict chemistry control. He created some controversy by emphasizing that the very large improvements in chemistry specifications and control had not been matched by a corresponding decrease in tube failures. He viewed intergranular stress corrosion cracking and intergranular attack (IGA) from the outside surface as the chemistry driven mechanisms of concern.

J. Van Berlo of AECL-CO presented the CANDU story on secondary side chemistry. He emphasized the few tube failures (<0.003%) to date but urged continued effort and vigilance because of the higher steam temperatures at Darlington than previous CANDU's.

The Japanese approach to secondary side chemistry was discussed by T. Hattori of Mitsubishi. They have 17 PWRs in operation. All units have condensate polishers, and 15 have deaerators. He indicated that full flow condensate polishing will eliminate concerns with IGA, and commented on the dramatic difference between the effectiveness of full flow and partial flow condensate polishing.

L. Lepine of Hydro Quebec discussed the analytical work done to monitor trihalomethane production in the Gentilly-2 water treatment plant and the effect of temperature on their subsequent degradation. Chloroform is the principal product of the chlorination stage in the water treatment process. Chloroform ($CHCl_3$) decomposes in high temperature water to yield three chloride ions per molecule of chloroform, and hence is the main concern with trihalomethane production. Lepine discussed the modification of the Gentilly-2 water treatment plant that resulted in lower trihalomethane content in the feedwater.

An expert system to monitor and control the chemistry of the secondary side system, was described by R. Roberge of Queen's University. He believed the expert system was an excellent approach to secondary side chemistry control because of the thousands of inputs available. While superficially appearing complicated, the approach is really quite simple.

Two papers, one by Murphy of AECL and the other by Brennenstuhl of Ontario Hydro, reviewed major heat exchanger performance and current deterioration of tubes as a consequence of biofouling. The solution employed in most CANDU 6 units to avoid heat exchanger deterioration, with a cost penalty, is to use a controlled chemistry intermediate circuit between the river or lake and the heat exchange components. This has prevented tube failure. The part that bacteria play in the deterioration of tubes leading to through-wall perforation by pitting attack, was outlined by Brennenstuhl. Even minor variations in the composition of the sulphide inclusions in the metal of the heat exchange tubes led to significant variation in performance.

C.S. Welty of EPRI provided the maintenance and inspection session with a nicely condensed description of the PWR approach to inspection for tube damage and bundle fouling. J. Graham outlined the major inspection and maintenance activities of concern to Ontario Hydro.

The most serious problem currently experienced in Ontario Hydro steam generators is support plate blockage by crud. This disturbs the steam/water flow on the secondary side, leading to steam drum level oscillations at full power. Derating is required to eliminate the oscillations. A paper by Malaugh and Ryder of Ontario Hydro described a waterlancing technique used to alleviate the blockage. Further techniques, probably by chemical cleaning, will be needed to fully remove the blockage.

Advances in NDE of steam generator tubes and heat exchanger tubes were the subject of papers by Constantinou and Fouquet of Intercontrole and Cecco and Carter of AECL-Research, respectively. The Intercontrole paper described a total system of data acquisition and analysis from a remotely operated inspection probe. The CRNL paper described the design and performance of specialized eddy current probes and techniques to handle inspection of ferromagnetic tubes.

A very interesting paper in this session was a description of a miniaturized laser welding device using optical fibres to achieve sleeve-to-tube fusion welding inside the tube bore operated from a remote tool placed in the channel of the steam generator. The equipment was described by T. Kitera of Mitsubishi Heavy Industries. The technique is based on YAG laser technology.

In the design session, J.A. Rhodes of Northeast Utilities outlined the specification that they are applying to replacement steam generators for Millstone 2. This was followed by a presentation by Jim Smith who outlined the advances in the Babcock and Wilcox Canada steam generator design and the features contributing to its successful performance to date. T. Kusakabe of Mitsubishi Heavy Industries outlined the problems and solutions in future designs. N. Subash reported on the maintenance/inspectability and layout requirements of the CANDU 3 steam generators. The paper by R. Bouecke, presented by G. Schucktanz, described the replacement steam generators offered by Siemens/KWU for Ringhals (which incorporated integrated nozzles to reduce welding and IsI), and the tube to tubesheet joining procedure, (which included both hydraulic expansion and hard rolling to close the crevice). The design includes feedwater sparger to avoid waterhammer and thermal stratification.

In the materials and thermalhydraulics session, modelling behaviour of the CANDU 6 steam generator performance was described by M. Soulard of AECL CANDU. This was undertaken to establish the sensitivity of the performance to changes in various factors such as station operating conditions, tube fouling, recirculation ratio, support plate blockage and preheater leakage. He concluded that tube fouling is the main cause of the increased reactor inlet temperature seen in all units. The development of a model of sludge accumulation was described by Y. Liner of AECL-Research. This development has proceeded to a stage of describing behaviour of suspended and deposited magnetic particles. S. Yashima outlined a five year program in Japan to establish the effectiveness of counter measures to deal with tubing problems. A paper by Murphy and Winegar described procedures developed to lower surface residual stresses in bent and straight Incoloy 800 steam generator tubing.

In the first research and development session Philippe Berge of EDF provided an excellent overview of the problems of steam generator performance that have led to research programs and the solutions applied. He made the important point

that it is preferable to strive for increased availability rather than higher performance, and that there is a need for good communication between researchers and decision makers in design and construction.

The problem of solute concentration was discussed by P. Balakrishnan of AECL-Research. The experimental technique evaluated the various factors such as heat flux, crevice dimensions, crevice fouling and bulk flow rate on solute concentration. He pointed out that the concentration process has inherent variability from the nature of the steam blanketting effect and the opposing effects of diffusion of solutes and heat flux driven water flow. Mathematical models of crevice impurity mechanisms were also the subject of a paper by Millett and Fenton of the University of Connecticut.

The important subject of chemical cleaning was reviewed in three papers by LeSurf of Pacific Nuclear Services; Hansen of Babcock & Wilcox; and Odar of Siemens. LeSurf reviewed the development of the SGOG solvents and the extension to higher temperature solvents proposed by Pacific Nuclear. The B & W paper outlined the process development leading to full scale cleaning operations at Oconee and further development of the process. Odar reviewed the Siemens process used at Ringhals 3 and 4.

The final session was opened with a review of CANDU related research and development studies by Jim Brown of Ontario Hydro. In a following paper, F. Pement of Westinghouse Electric Corporation showed convincing evidence of the advantages of hydraulic expansion over "kiss" rolling (mechanical stress relief) procedures for sensitized Inconel 600, as well as the advantage of the thermally treated I600 over the mill annealed condition. The tests were done in 400° C steam with a partial pressure of hydrogen and in rolled joint capsules with a differential pressure. The inability to crack I800 by stress corrosion cracking in high hydrogen, high oxygen primary side environments was demonstrated in results presented by F. Peca of AECL-Research.

The remainder of the session was devoted to flow induced vibration in a series of papers presented by AECL-Research and CEA authors. Vibration exclusion mechanisms were reviewed by M. Pettigrew and the techniques to model dynamic interaction between vibrating tubes and their support. C.E. Taylor of AECL-Research described the performance of flat bar U-bend restraints in two-phase cross flow while J.L. Compan described the progress in the Clotaire program to qualify PWR steam generator computer codes describing thermalhydraulic conditions and flow induced vibrations. This program continues with experiments in both boiler and axial economizer configurations.

The poster session, combined with a wine and cheese party successfully provided an opportunity to review a number of papers in detail. A prize for best poster paper was awarded to M. Takemoto of Kawasaki Heavy Industries for his presentation on "Heat Transfer Augmentation in Post Dryout Region with Inserted Enhancers".

The general consensus of the 167 delegates who attended was that the conference fully met their expectations. It was truly international with delegates from the USA, Japan, France, Germany, Sweden, Spain, England, Korea, China and, of course, Canada attending.

CNS 11th Annual Conference

June 1990

compiled by Ben Rouben

Session 1: Programs and Issues for the 90's

CANDU 3 – Ready to Build K.R. Hedges and E.M. Hinchley.

Integrated Plant Design G. Tolpa.

Requirements for Advanced Reactor Designs A. Natalizio and D.F. Rennick.

The Program to Develop and Demonstrate the CANFLEX Bundle, Its Additional Capabilities and Supporting Technologies A.D. Lane *et al.*

Facility Requirements for an NRU Replacement K.S. Kozier *et al.*

Review of Canadian Contributions to the Design of ITER R. Stasko *et al.*

The first two papers in this session addressed aspects of the design of AECL's CANDU 3 reactor. The paper by Hedges and Hinchley described the advanced status of the design and the plans for construction, licensing and project execution which are much further developed than on previous designs at the pre-project phase. The following paper by Tolpa described the tools and work processes used to achieve an integrated plant design, with emphasis on computer aided design and drafting (CADD) and other computer-aided modelling, analysis and design tools.

Natalizio and Rennick presented developments on the international scene in the area of new designs intended to achieve higher levels of safety. The prime objective appears to be a more stable and predictable licensing process through standardization, design certification, and one-step licensing. This interesting paper was followed by a description by Lane *et al.* on the program to develop and demonstrate the CANFLEX bundle, which is intended to meet the envisaged needs of CANDU reactors over the next 5 to 25 years. This bundle design, with two different element sizes, can operate at current bundle powers with larger operating and safety margins, or alternatively could achieve higher bundle powers with the same margins. The higher burnups required for optimum use of advanced fuel cycles can also be achieved with this design.

The facility requirements for the Advanced Maple research reactor were described by Kozier, *et al.* This reactor, intended to replace the NRU reactor at Chalk River, would have higher neutron flux than NRU, but a lower total core power. It would be used for materials irradiation experiments and applied research using extended neutron beams, as well as playing a back-up role to the MAPLE X-10 reactor for the production of commercial isotopes.

The final paper in the session described the Canadian contributions to the design of the International Thermonuclear Experimental Reactor. Canadian agencies, coordinated through the Canadian Fusion Fuels Technology Project, have made significant contributions to the reference design of this experimental fusion reactor being developed by an international team centred at the Max Planck Institute in West Germany.

J.D. Harvie

Session 2: Thermohydraulics I

Transient Effects on Critical Heat Flux and Quenching in Directly Heated Tubes S.C. Sutradhar *et al.*

Analysis of LOCA Experiments in the RD-12 Parallel-Channel Test Facility N.K. Popov and G.R. McGee.

Tabular Approach to Predicting Critical Heat Flux D.C. Groeneveld and L.K.H. Leung.

Commissioning the Two-Pump Mode of Operation at the Point Lepreau Generating Station M. El-Hawary *et al.*

Measurement of Enthalpy Migration in a Horizontal Test Assembly with Two Interconnected Subchannels S.T. Yin and C.W. Snoek.

Bubble Migration in Horizontal Tubes and Rod-Bundle Geometries S.I. Osamusali *et al.*

The diversity and detail of investigation covered by this session is a good indication of the maturity of Canadian thermalhydraulic development. The various papers each reported on studies of considerable depth, focussing on particular niches in the field of nuclear thermalhydraulics.

Two CRNL Papers (Sutradhar *et al.*, Groeneveld *et al.*) dealt with CHF experiments. In the first, transient effects on CHF were investigated for typical CANDU overpower conditions. A significant observation was the slight increase in CHF for power-rise conditions. In the second, Dr. Groeneveld reported on the continued development and application of the tabular approach to CHF estimation, now available for application to CANDU fuel bundles, and in increasing use world wide.

Popov *et al.* presented a review of the various phenomena seen in some early CANDU LOCA experiments; parallel channel blowdown/ECC tests in the RD-14 loop. Of particular interest were variations in behaviour between the two parallel channels, such as bidirectional flow. This point raised considerable discussion, and will focus attention on future tests in the RD-14 5-channel-per-pass loop.

El-Hawary *et al.*'s paper on the work to commission Point Lepreau NGS for 2 pump operation demonstrated the level of detail and accuracy now expected of thermalhydraulic plant simulation codes. It is encouraging to see papers which highlight the plant operation aspects of this subject.

The final two papers addressed subchannel flow behaviour in fuel bundles. Yin *et al.* demonstrated that enthalpy migration from lower subchannels to upper subchannels is a significant function of overall flow rate, even under normal fuel channel flow conditions. Osamusali *et al.*'s paper showed that upward bubble migration, on the other hand, is restricted by narrow inter-element gaps, lead into higher local bubble void fraction. These papers continue the progress in understanding the detailed phenomenology of channel flow and CHF effects.

J.M. Hopwood

Session 3: Reactor Physics and Fuel Management

Application of Local-Parameter Lattice Properties to Fuel Management Simulations in Ontario Hydro Reactors L. Wilk *et al.*

Fuel Management Flexibility with Single-Ended Refuelling in CANDU 3 A.M. Manzer and H.C. Chow.

The Influence of Lattice Structure and Composition on the Coolant Void Reactivity in CANDU A.R. Dastur and D.B. Buss.

Fuel Management Simulation of CANDU 3 at Equilibrium Condition M.H. Younis.

Transient Analysis of a Postulated Reactivity Insertion Accident in the MAPLE X-10 Reactor using the Code TANK R.J. Ellis.

Neutronic Decoupling and Coolant Void Reactivity in CANDU V.K. Mohindra and A.R. Dastur.

This session offered an interesting combination of papers on analysis work in reactor physics and fuel management. They covered improvements in refuelling simulation methodology for existing reactors, fuel management studies for the CANDU 3 design, physics analysis for future reactors and neutron dynamics analysis for safety assessment of the small MAPLE X-10 isotope production reactor.

Les Wilk of O.H. summarized an assessment of the merits of specifically accounting for the spatial variation of fuel temperature and neutron flux variations in the calculation of the lattice parameters used for fuel management simulations of O.H. reactors. He concluded there's a potential benefit of about 1% reduction in peak bundle power for a given reactor output.

Al Manzer and Mohammed Younis of AECL CANDU discussed detailed studies of various fuel management schemes for the CANDU 3 project which would yield acceptable fuel defect probabilities and limit peak bundle powers to the desired levels. These studies led to adopting a scheme for reference design purposes which produces significant flattening of the power distribution axially.

Adi Dastur of AECL CANDU gave a paper on the ways in which current fuel designs could be adapted to reduce the loss-of-coolant reactivity in CANDU to zero. It involved adding a neutron absorber to the central 7 elements of a standard 37 element CANDU fuel and using fuel enriched in U_{235} in varying degrees across the bundle to compensate. Adi also described a methodology which could permit a simple means to assess the benefits of PHT circuit subdivision in reducing the reactivity effect of a loss-of-coolant in future CANDU reactor designs.

Ron Ellis of AECL-Research (WNRE) summarized results of neutronic transient analysis of a postulated ejection of a reactivity hold-down rod from the 10 MW MAPLE X-10 reactor being designed for isotope production at CRNL. He concluded that the inherent negative reactivity feedback characteristics of this design would prevent serious consequences from this low probability event.

All of the papers prompted several questions from the audience which indicated they were found to be interesting and useful.

A.A. Pasanen

Session 4: Nuclear Safety

Improving CANDU Safety with Organic Coolant N.J. Spinks.

Catalytic and Spark Hydrogen Igniters R. Heck.

Development of Analytical Methods to Evaluate the Integrity of a Calandria Tube in the Case of Pressure Tube Rupture Y. Morishita *et al.*

CHAN-II (Mod 6) – Further Verification Against Seven Element Experiments M. Bayoumi *et al.*

Rupture d'une conduite côté secondaire Gentilly 2 (Gentilly-2 Secondary-Side Break Study) P. Lafreniere and R. Shill.

In the first paper, Norm Spinks presented some of the potential safety advantages of the organic cooled CANDU reactor over the existing PHWR designs, and implied that this concept should be reconsidered in context of future designs. Some of the advantages cited by Spinks were:

- The use of high conductivity uranium carbide fuel which leads to significantly lower normal operating fuel temperatures and reduced diffusion of fission product gases from the fuel matrix to the gap. This reduces fission product release in accidents by 2 or 3 orders of magnitude.
- The lack of steam to fuel the exothermic metal water reaction for LOC/LOECC accidents, again leading to much lower fuel temperatures and fission product release.
- A lower operating pressure which reduces the discharge rate from the primary circuit in the event of a LOCA. Although the OCR has a higher void coefficient, the lower voiding rate means that the rate of reactivity addition for the OCR is only half of that expected for the PHWR.

Due to the above advantages, the ECC System (including the need for boiler crash-cool) can be either substantially downsized or eliminated.

Because of the higher operating temperature leading to higher plant thermodynamic efficiency, and the lower cost of coolant, it is believed that an OCR could lead to an overall plant capital cost reduction of 10 to 15 per cent. This combined with a number of safety advantages leads Spinks to conclude that this design concept should be given further consideration in context of future CANDU designs.

In the second paper, Reinhard Heck discussed the details of two new designs of hydrogen ignitors developed by Siemens. The catalytic and spark ignitors were designed to overcome the

problems of the current glow plugs and hot coil ignitors which require the high capital cost associated with cabling and providing electrical power from outside of containment.

Reinhard discussed the principles of operation and the design of each of the new ignitors, and outlined the qualification program that has been performed to support their use in power reactors to control the hydrogen gas that is released following a severe loss of coolant accident.

In the fourth paper, Yoshitsugu Morishita outlined the details of an analytical model which had been developed to evaluate the integrity of a calandria tube in the event of a pressure tube rupture. Yoshitsugu presented some experimental results and discussed the comparison that had been made with the model. The results showed good agreement in predicting the pressure transient within the annulus and favourable agreement on the structural analysis in predicting the strain behaviour of the calandria tube.

In the fifth paper, Mohamed Bayoumi presented the results of the latest series of comparisons that are being performed at Ontario Hydro to validate the CHAN-II (Mod6) code against experiments. The comparison against both the vertical single element and 7 element tests clearly showed that CHAN-II does an excellent job in capturing the principal heat and mass transfer mechanisms.

In the sixth and final paper, Paul Lafreniere discussed the extensive study that had just recently been completed and submitted to the AECB, on the consequences of a postulated steam or feedwater line break occurring in the turbine Hall at the Gentilly-2 Nuclear Generating Station. The study, performed in response to an "action item" identified by the Atomic Energy Control Board, was conducted by AECL and considered the main safety criteria of: reactor shutdown, heat sink availability, containment isolation, and monitoring. Probabilistic techniques were employed to assess the effectiveness of both the group 1 and 2 systems. The analysis identified the potential benefit of a number of modifications that could impede the propagation of steam throughout the station and to ensure a secure assess to the Secondary Control Area.

P.D. Thompson

Session 5: Small Reactors

Preconceptual Study of an Advanced MAPLE Research Reactor J.V. Donnelly *et al.*

Enhanced Boiling Heat Transfer for the SLOWPOKE Decay-Heat Rejection System M.J. Brown *et al.*

Thermalhydraulic Modelling of the MAPLE Research Reactor S.Y. Shim *et al.*

Full-Scale Thermohydraulic Tests of the AMPS Reactor System T.C. Currie and J.C. Atkinson.

Addition of a Gravity Separation Model to COBRA-IV for Use in AMPS Thermohydraulics Analysis A. Tahir.

The first paper by Donnely *et al.* presented the neutronic modelling of the Advanced MAPLE Reactor proposed as a possible future replacement for the NRU research reactor at CRNL. The major design issue addressed by the authors was the choice of light or heavy water as coolant. It was shown that heavy water presents a number of neutronic advantages, including a higher flux at the central testing site, reduced fuel requirements and enhanced core lifetime, with comparable reactivity coefficients.

The second paper by Brown *et al.* reported the results of an MS thesis at Carleton introducing a wickless heat pipe concept for decay heat removal in a SLOWPOKE Energy System reactor (SES). The decay heat removal system uses a water-filled annular evaporator located in the SES pool, a natural-convection-cooled condenser rejecting heat to the ambient air outside the reactor building and a buffer gas above the water which prevents the system from functioning during normal reactor operation. The paper presented measurements on a half-scale pipe system to investigate the heat transfer characteristics of evaporator surfaces. Experiments showed in particular that using Teflon wire-wrapped surfaces improved significantly the heat rejection at a given pool temperature.

Shim *et al.* presented the thermalhydraulics modelling of the MAPLE reactor. They used MAPL3D to study the 3-D flow patterns in the chimney and the pool, and the SPORTS-M and CATHENA one-dimensional codes to analyse the transient thermalhydraulic behaviour of the system and establish core cooling capability during normal and upset conditions (eg. guillotine break at pump discharge line). These codes have been validated against experiments performed in support of the MAPLE program.

The last two papers in the session dealt with the AMPS reactor thermalhydraulics. In the paper by Currie *et al.*, experimental results on the test facility at Stern Labs were presented. The objective was to verify those aspects of the design related to exchange flow suppression under normal operating conditions and the provision of passive cooling under accident conditions. The measurement of exchange flows with the reserve cooling tank were described, and results of a stable by-pass flow of less than one per cent was reported under normal flow conditions. By-pass flows are well predicted by the TRACT model.

The AMPS system is designed for submarine propulsion. Prediction of critical heat flux (CHF) margin must therefore account for submarine inclination. The paper by Tahir described the addition of a gravity separation model to the subchannel analysis code COBRA. The code was modified by adding a vapour flow term to the equation governing the cross flow between adjacent subchannels, based on an average vapour velocity in the transverse direction. This modification was verified against ASSERT results on a CANDU bundle, with an agreement of ± 10%.

D. Rozon

Session 6: Fuel Behaviour

Preparation and Applications of Simulated High-Burnup Nuclear Fuel R.A. Verrall *et al.*

Behaviour of Braze Heat-Affected Zone in CANDU Fuel Sheaths N.A. Graham *et al.*

Influences of Load Following, Partial Dryout, and End-Flux Peaking on Temperature Distribution in CANDU Fuel S. Girgis *et al.*

Characterization of Fuel Failures Resulting from the November 1988 Overpower Transient in Pickering NGS-A Unit 1 M.R. Floyd *et al.*

CANDU Fuel: The Use of Zirconium Barrier Layer Cladding as an Alternative to CANLUB to Prevent PCI Failures T.J. Carter *et al.*

A Preliminary Analysis of Fission Product Releases in the HEU-Fueled SLOWPOKE-2 Reactor B.J. Lewis *et al.*

The session on Fuel Behaviour dealt primarily with studies to examine or extend the performance limits of CANDU fuel, with one paper describing the interpretation of noble gas release from a SLOWPOKE-2 reactor core.

The paper by Verrall *et al.* described the fabrication and use of SIMFUEL to study, out reactor, the influence of expected concentration of selected fission products on the diffusional release of fission gas from UO_2 fuel at high burnups. The results indicated little direct effect of composition on diffusion coefficients implying that the explanation for higher gas release may be due either to changes in thermal conductivity or porosity of the fuel matrix.

The paper by Carter *et al.* presented initial results on the use of Zirconium barrier layer cladding as an alternative to CANLUB for preventing Stress Corrosion Cracking (SCC) due to Pellet/Clad Interaction (PCI) in high burnup CANDU fuel. As expected, the interim results of low burnup indicated that the Zirconium layer is as effective as CANLUB.

The paper by Graham *et al.* noted that while sheath material properties were not limiting parameters in CANDU fuel, properties of the as-received Zircaloy-2 sheathing were consistently better at normal operating conditions than those in the annealed condition typical of braze heat affected zones.

Girgis *et al.* presented analysis results using two dimensional finite element analysis code FEAT. These provided an indication of the magnitude of thermal effects due to non-symmetric heat transfer conditions in operating fuel elements, which are usually not explicitly accounted for in the faster running "symmetric" codes.

Characterization of the November 1988 fuel failures in Pickering NGS by Floyd *et al.* indicated that the primary failures were caused by PCI induced SCC due to ramping above the threshold power during a power increase following a reactor trip. It was concluded from the extensive analysis and cell examinations that these failures would not have occurred if the existing reactor power guidelines had been exceeded. Because the ramped power and burnup for much of this fuel were beyond those of the existing database, upon which current fuel behaviour models are based, this data represents an effective extension of the database on failure thresholds. Further work to incorporate more of this new data into the existing database was recommended.

The paper by Lewis *et al.* described gamma-ray spectrometer analysis of the short-lived noble fission gas isotopes detected in the gas head space of a SLOWPOKE-2 reactor, and showed that the release from the Al clad U-Al fuel alloy is controlled by diffusion, as is the transport from the coolant into the gas head space.

P.J. Fehrenbach

Session 7: Energy Production and the Environment
report not available

Session 8: Computer Applications – report not available

Session 9: Nuclear Systems

Design and Installation of D20 Sampling System for Bruce 'B' A.G. Norsworthy *et al.*

A Review of the New Canadian Standard for the Support Power Systems of CANDU Nuclear Power Plants B.A. Rolfe *et al.*

Pickering 'A' NGS – Calandria Vault Corrosion Program A.N. Sangwine *et al.*

The CANDU 3 Control Centre Design R.F. Moore and J. Hinton.

A New Approach to Control and Monitor CANDU Fuel-Changing Operations Using 'On-Board' High-Temperature/Radiation-Hardened Electronics R. Anderson *et al.*

The first paper described an improved D20 sampling system for the primary heat transport system of a CANDU reactor, designed to accurately monitor fuel channel conditions with a view to controlling deuterium buildup in pressure tubes. Because the coolant chemistry changes rapidly once it enters the feeders, sampling speed and take-off location are critical. A modified seal ring with a radial access hole was installed in Bruce B between the end-fitting and feeder hub as the take-off point. The remainder of the system rapidly depressurizes and transports the sample to analyzers within 2 minutes.

A new CSA standard N290.5 covering the supporting Electrical Power and Instrumentation Systems of CANDU Nuclear Power Plants was recently issued. Based on experience from the design and successful operation of existing plants, it considers that the design of supporting power systems is ultimately determined by the requirements of special safety and safety related systems. Numerous notes are provided on typical practices to contribute insight into well proven design approaches.

Radiation effects on moisture accumulated in the Pickering A calandria vaults has produced nitric acid. This corrosive environment has led to pipe leaks and corrosion cracking of highly stressed components. Initially, leaks were temporarily sealed. The paper describes a program to permanently control and correct damage, including installation of a vault drying system plus remote evaluation and repair.

The third generation CANDU 3 control centre emphasizes human factors in the layout, reflecting evidence that teams problem solve best when working from a common display. An enlarged wall graphics screen is made the viewing focal point. The safety analysis is interfaced with the plant system display so that each safety credited display is traceable to the source instruments, controls and the safety related operator actions and procedures. This integration will allow the operator to respond immediately, fully aware of the situation and rules to be applied.

All CANDU fuel handling systems previously used catenary cabling for fuelling machine control and communication. Catenary cabling poses design problems, lacks expansion capability and has limited flexibility for changes. The CANDU 3 design, facing space restrictions, is developing radiation hardened electronics to be placed on-board the F/M, eliminating 22 cables of 40mm diameter. A prototype system is scheduled for installation and test at Bruce B.

J.A. Blasko

Session 10: Fusion

The Industrial Benefits of Fusion Arising from the Canadian Fusion Fuels Technology Project J. Robinson and A.B. Meikle.

Radiolysis of the Aqueous Lithium Salt Blanket A.J. Elliott and M.P. Chenier.

Two-Dimensional Model of Temperature Distribution and Stresses in the TF Coils During Long Pulse Operation on the Tokamak de Varennes G. Le Clair *et al.*

Applications of Tritium Technology to Fusion J.M. Miller *et al.*

Fusion Solid-Breeder Irradiation Experience at CRNL R.A. Verrall and J.M. Miller.

The first paper, given by J. Robinson, reviewed the success that CFFTP has had in marketing fusion-related goods and services abroad. Hardware, engineering and research services contracts totalling about $6M were arranged through CFFTP in fiscal 1989/90. Major new opportunities for the Canadian nuclear industry in the fusion area are offered by the International Thermonuclear Experimental Reactor project.

R. Verrall presented the paper on radiolysis of the aqueous lithium salt blanket on behalf of the authors. A major safety concern in this system is radiolytic oxygen formation that could lead to potentially explosive hydrogen-oxygen mixtures. The experimental data suggests that the lower limit for the hydrogen over-pressure required for oxygen suppression is in the range of 150-200 kPa compared to the 5-50 kPa typical of fission reactors.

The calculations of G. LeClair *et al.* employed a two-dimensional finite element algorithm to predict the suitability of the toroidal field (TF) coils of the Tokamak de Varennes for long pulse (32 s) operation. A detailed study of the temperature evolution for several scenarios and comparison with relevant measurements indicates that the designed TF coil cooling arrangements will permit long pulse operation of the tokamak.

L. Rodrigo reviewed the extensive fusion-related tritium work that has been done at Chalk River largely in collaboration with CFFTP. Key areas discussed were metal getter technology, monitoring and analysis of tritium, isotope exchange on molecular sieves and fusion fuel cleanup systems.

R. Verrall discussed the solid breeder blanket program, co-funded by CFFTP and AECL, which is centred on irradiation tests in NRU. In particular, he reviewed the CRITIC-I test of lithium oxide that lasted for two years and produced the highest lithium burnup of any such irradiation in the world. Several new effects were observed.

D.P. Jackson

Session 11: Reactor Decommissioning, Irradiated Fuel, and Materials Handling

Container Storage of CANDU Fuel: Ontario Hydro's Dry Storage Demonstration Program R.N. Sumar *et al.*

Calculation of the Radioactive Inventory of the Decommissioned NPD Reactor W.M. Smith.

Environmental and Safety Assessment on the Conceptual Design of the Used Nuclear Fuel Disposal Centre – Occupational Radiological Assessment and Preliminary Results M. Zeya and D. Petras.

Tritium Gas Handling Using Tritide Forming Materials W.T. Shmayda and A.G. Heics.

The papers in this session covered a broad range of activities relating to the handling and storage of radioactive materials. The first paper, given by Armstrong, described the development of concrete containers, by Ontario Hydro, for dry storage of irradiated CANDU fuel. Full-scale containers have been constructed and tested for both storage and transportation. Scale-model tests have demonstrated the robustness of the concept and the viability of new, more efficient designs, based on non-round containers.

Smith described the calculational procedure used to estimate the radioactive inventory remaining in the decommissioned NPD reactor. This calculation is the first attempt to obtain a full inventory in the metal and concrete shielding of a CANDU-type reactor using the complete power/flux history of the reactor. The results give some guidance on the time the reactor should be kept in a sealed condition prior to final disassembly.

One factor in the acceptability of the concept for underground disposal of irradiated CANDU fuel, is the safety of the workers involved. Based on the conceptual design developed by AECL and Ontario Hydro, Zeya and Petras have estimated normal and extraordinary (accident conditions) radiation exposures and concluded that non-radiological risks will dominate occupational safety and that radiation doses will be well below regulatory limits.

There is an increasing need to develop safe and efficient tritium scavenging and storing technologies. Schmayda described advances at Ontario Hydro in the use of uranium and zirconium metals as storage media. More work on the development of efficient scavenging alloys is in progress.

D.J. Wren

Session 12: Thermalhydraulics II

Development of a Model to Predict CHF Enhancement in Subchannels with Spacing Devices K.F. Rudzinski and C.W. Snoek.

Turbulent Flow Structure in Subchannels of a 37-Element Bundle S.C. Sutradhar.

An Efficient Heat-Transfer Prediction Package Suitable for Steady-State and Accident Analysis L.K.H. Leung and D.C. Groeneveld.

Two-Phase Pressure Drop and Wall-Temperature Measurements L.K.H. Leung and D.C. Groeneveld.

All four papers described the experimental and analytical work that is on-going in Chalk River Nuclear Laboratories in support of improvements of CANDU fuel design and performance.

The first paper, presented by S.C. Sutradhar, described a newly developed local CHF correlation which accounts for quality, mass flux and bundle appendages enhancement. The experiments performed in different test assemblies with simulated interconnected subchannels indicated that the heat transfer is enhanced downstream from a spacer plane. New 'enhancement factor' takes this into account and it can remove some conservatism from predictions of CHF in fuel bundles.

Sutradhar also described experiments to determine the velocity distribution in subchannel geometries and to study by the influence of the wall curvature, that bounds the subchannel (e.g. pressure tube), on turbulence in outer subchannel of fuel bundle. Tests were performed in an upscale (13:1) model of 37-element fuel bundle, with air as the working fluid. Test data show good agreement with previously performed tests and correlations, and show that the influence of the curvature of the subchannel on the velocity distribution and shear stresses can be included in subchannel thermalhydraulics.

A software package, as described by L.K.H. Leung, has been developed to evaluate the heat-transfer rate and flow regime in convective boiling, and provide the thermodynamic and transport properties of fluids such as light water, heavy water, freon, etc. It is organized in a user-friendly form for the IBM-PC AT/XT or other compatible microcomputers, but can also be used on mainframes and integrated into large reactor-safety codes. Prediction methods and correlations employed in this package are selected mainly for their accuracy, wide range of conditions, and correct parametric and asymptotic trends.

Measurements of critical heat flux (CHF), post-dryout (PDO) pressure drops and wall temperatures in two vertical electrically heated tubes with upward flow of light water produced some interesting data, that can be of use in safety analyses. Test parameters such as pressures, temperatures and flow rates were close to reactor operating conditions, and tests results are applicable to the loss-of-regulation accidents. It was observed that the pressure drop across the test section increased with increasing power in pre-dryout region, but decreased when approaching dryout. Beyond dryout, the pressure drop continues to decrease and bottoms out when stable film boiling is achieved and then begins to increase with increasing power. A hysteresis was also found when experiments were performed with decreasing power.

J.Y. Stambolich

Session 13: Reactor Components

CANDU Fuel Channels – Overview of Pressure Tube Manufacturing and Influence of Technology Developments E.G. Price and J.F. Slavik.

Calandria Vessel Structural Integrity Under a Channel Flow Blockage/ Loss of Coolant Accident Condition S.S. Dua *et al.*

Design and Development of a Mechanical Zone-Control Unit for the CANDU 3 Reactor R.S. Porter and J.F. Cameron.

CANDU 3 Rolled-Joint Development Program S. Venkatapathi *et al.*

Use of a Thick Pressure Tube for CANDU Power Plants Cost Optimization S.S. Dua *et al.*

Prospects for Stronger Calandria Tubes C.E. Ells *et al.*

This Session, comprising six excellent papers, was extremely well attended considering the time and competition; last Session in afternoon on last day of Conference and the Jays playing an afternoon game at SkyDome. In total, approximately 40 people were present throughout the Session, and they were entertained by a variety of papers.

J.F. Slavik of AECL CANDU presented an overview of the various methods that have been and still continue to be used to fabricate CANDU pressure tubes. The current manufacturing process was outlined in great detail and a review of the various Specifications and processing parameters was given.

The second paper, presented by T. Lee, was titled "Calandria Vessel Structural Integrity Under a Channel Flow Blockage/ Loss of Coolant Accident Condition". Lee presented the results of a mathematical analysis used to model the response in the calandria vessel to pressure tube blockage as a result of a LOCA. Lee showed that, even under severe blockage conditions, where the channel fails and ejects hot fuel into the calandria vessel, the calandria assembly pressure boundary and heat sink capability are not compromised. A spirited discussion followed Lee's presentation.

Next, Porter reviewed the requirements for reactivity control devices in CANDU reactors. In current reactors, Liquid Zone Controls (LZC) are used with their attendant complex and costly fluid systems. In the new CANDU 3 design, a Mechanical Zone Control (MZC) unit has been designed that gives equivalent performance with significant cost savings. Porter detailed the design of the new MZC and the complex series of tests that had been undertaken to ensure adequate performance of the unit in service.

A most entertaining paper was presented by "Venki" Venkatapathi. The audience was regaled by many anecdotes associated with the development of the rolled joint installation procedures to be used in CANDU 3. Existing procedures were reviewed and compared to those developed for CANDU 3. This paper served as a refreshing interlude in the afternoon proceedings and was appreciated by all those in attendance.

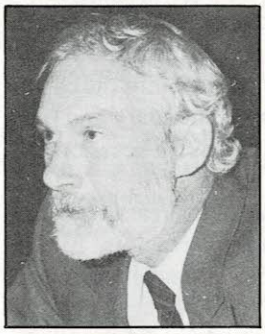
S.S. Dua of AECL CANDU reviewed improvements in CANDU NPP economics that may derive from the use of thicker pressure tubes. The thesis of his presentation was that, with the advent of advanced fuel cycles, pressure tube thickness was no longer a limiting factor in neutron efficiency and improved thermodynamic performance could be gained using thicker pressure tubes. Dua was able to show that the neutron penalty for using a thicker pressure tube was far outweighed by an improvement in thermodynamic efficiency. As a result, an increase in pressure tube thickness of 0.7 mm, upgraded the pressurized heat transport system to provide 5% more power and this in turn resulted in a 5% saving in plant specific capital cost. The penalty, using a 1.4% enriched fuel was shown to be equivalent to 0.0196% U-235 or less than 1 m/kWH TUEC.

The last paper of the Session was presented by C.E. Ells of AECL Research. Ells reviewed the options available to produce stronger calandria tubes. Currently, calandria tubes are made from seam welded and annealed Zircaloy-2. Options for improvement included but were not limited to different manufacturing processes and metallurgical condition, different chemical composition and different welding techniques and weld configuration. Ells concluded that a weld that was thicker than the parent alloy coupled with an increase in oxygen content would be a good intermediate approach to take to strengthen calandria tubes. Seamless tubing would be a long-term goal if the economics warranted the increased cost.

Harvey R. Lee

The AECB Prepares for the Challenges of the 90s

René J.A. Lévesque, President, Atomic Energy Control Board



Dr. René J.A. Lévesque

Address to the Canadian Nuclear Society, Toronto, June 6, 1990

Forty-six years ago today, the Allied Powers landed in Normandy in an ultimately successful quest to establish world peace and security. A little over two years later, a unique Canadian organization was established by a government interested in maintaining that peace and security with respect to the awesome power of the atom.

In the beginning, this translated into the fundamentals of non-proliferation or safeguards work for the fledgling Atomic Energy Control Board, which managed to discharge its growing responsibilities with a staff of less than a half-dozen until the early 60s.

Safeguards work has always been an important facet of AECB operations, but it was the concern for health and safety in connection with a growing number of nuclear energy applications in the 50s and early 60s that established the Canadian nuclear regulatory agency's next great challenge. The first regulations dealing with nuclear health and safety came into being in 1960.

From 1965 to 1975, the AECB grew slowly but surely, nevertheless depending heavily on outside resources such as advisory committees to fulfil its mandate. In the period 1975-1985, when nuclear power experienced its greatest growth, the AECB staff increased four-fold, to nearly 270, but then shrank slightly under the influence of federal belt-tightening programs.

It is the post-1985 period that I will focus on today, explaining why it is that while the theme of this year's CNA/CNS conference is *being* ready for the 90s, the title of this address refers to the AECB's *getting* ready.

When I became a member of the Control Board in 1985, I was amazed to find so many of my otherwise very knowledgeable friends and colleagues totally ignorant of the very important agency I'd joined.

And, though I don't think I'm a vain person, I was somewhat surprised that my appointment in 1987 as president of the AECB, and the first francophone in that post, resulted in but one small news media mention – in the Montreal *Gazette*. Once again I encountered people I knew who were totally unaware of Canada's nuclear regulatory body.

This lack of visibility for the AECB has continued to concern me.

From the perspective of the president's chair it did not take me long to realize that not only was the AECB practically invisible to the public it serves, but also it lacked the resources necessary to be a truly effective regulator in the short term, and in the decade to come. Not that the agency was doing a bad job, but it was becoming more and more difficult to state confidently that a good job was being done in all areas.

The Board's mission is to ensure that the use of nuclear energy in Canada does not pose undue risk to health, safety, security and the environment. We were getting to the point, particularly in the areas of reactor safety and the transportation and use of radioisotopes, that our limited resources could do less and less ensuring of low risk in the face of rapid technological developments and industry size.

My own realization of the shortcomings was confirmed by both the 1988 report of the House of Commons Standing Committee on Energy, Mines and Resources, and the 1988 Ontario Nuclear Safety Review, which expressed the judgment that the AECB was deficient in money and manpower.

This state of affairs could not be allowed to continue or we could be in breach of our duty to atomic radiation workers and the public. Accordingly, a detailed case for increased staff and financial resources was presented to the government about a year ago. It called for a very substantial increase in the financial and personnel resources available to the Board over a five-year period.

The supporting arguments were based on the important job to be done and the resources required to do it, but also included comparisons with the resources available to nuclear regulatory bodies in other countries. For instance, we found that the regulatory authorities in the U.K., Sweden, France and the U.S. have from one and a half to four times as many staff resources per power reactor as the AECB, and spend a good deal more per unit. Another important point is that due to similar reactor technologies, these and other countries have more of a capability to share operating, regulatory and research experience, whereas Canada stands pretty much alone with the CANDU design.

Comparisons with other countries are fraught with uncertainties. Obviously, the number of dollars spent per reactor or the number of inspectors per licensee is not a direct measure of a regime's inherent safety – regulatory style or approach has a great deal to do with it. However, it does provide a basis for comparison when introspection suggests change is necessary. With the Stanley Cup just behind us, it might be appropriate to cite a hockey analogy; we all know that the number of players on a team is no guarantee of a winner. But a coach with a small roster, looking for improvements to his team's performance, might be influenced to do some serious recruiting if all the other teams played with more breadth and depth on the bench.

Last fall the government responded to the AECB submission with approval for some 100 additional staff positions and a total of just over $25 million in additional funding in the

next couple of years. That was less than when we'd requested over a five-year period, but realistically we could not spend money or hire staff at a greater rate in just two years without compromising the efficiency and effectiveness the new resources were intended for in the first place.

All in all it was a remarkable sign of support from our government, given the climate of restraint in government spending. I feel that it shows the government's interest in sustaining a safe nuclear industry, as well as its rapid recognition that a number of areas needed attention in the public interest. The Board is very grateful to our Minister, the Honourable Jake Epp, for his full and consistent support in our quest for these resources. And I am pleased to note that he will be giving further study to our requirements beyond what has already been granted.

Our new resources will permit us to do a number of things. Overall we will improve the depth and rigor of the regulatory audit. In the area of power reactors, the review of analyses will be more thorough and quicker. Human factors will get more attention, as will the requalification of reactor operators. Technical reviews and inspections will gain in depth and scope. We will have the ability to become involved earlier in uncommitted projects like the CANDU 3 and the SES-10, ensuring AECB criteria are met at the design stage. Emergency preparedness will get attention, and the many AECB policies and requirements that have been developed over the years will be codified and documented.

In the transportation and use of radioisotopes, inspection will be stepped up and new approaches to enforcement will be evaluated, such as fining by ticket. The AECB's mission-oriented research program will be expanded, particularly in the areas of reactor safety, waste management, and the development of radiation protection standards.

Last but not least, the AECB will be able to do more to improve its visibility. This will be achieved through staff communications efforts, as well as a greater openness in the Board's decision-making process. For example, April 1988 saw news reporters witness a portion of a Board meeting for the first time. And during the licensing of the first unit at Darlington last fall, the presence of journalists and intervenors at Board meetings became commonplace. I expect this kind of activity to increase, with the Board developing the ways and means to meet the needs of the interested parties effectively and efficiently.

We've even developed the beginnings of a sort of "road-show": this month alone the Board will have visited two communities before making decisions on issues of local interest. I have just returned from Saint John, New Brunswick, where the Board heard local views on licensing activities at the Point Lepreau Nuclear Generating Station. In two weeks, the Board will hold a public meeting and a Board meeting in the vicinity of the Bruce Nuclear Power Development. This fall it will travel to northern Saskatchewan to meet with the Hatchet Lake Indian Band prior to making a licence decision on Cameco's nearby Rabbit Lake mine.

Incidentally, as well as enhancing visibility, these activities assist the Board in complying with the Federal Environmental Assessment and Review Process Guidelines Order. Under this regimen, the Board must systematically assess the environmental impact and public concern associated with a proposal on which it must make a decision, and provide for access to information and public response at key stages. In reaching an opinion on something like the need for public review, it is obviously valuable to have had the benefit of direct input from the interested parties. Our new resources will facilitate the necessary encounters.

The AECB is not the only federal nuclear entity to get an infusion of funds recently. On March 30, the government announced that agreement had been reached for Canada's three nuclear utilities to share some of the cost of operating Atomic Energy of Canada Limited. The AECB welcomes this because of the obvious implications for nuclear safety, particularly as it pertains to the CANDU reactor.

It is intriguing to note that nuclear power today is in much the same position as consumer electricity was exactly a century ago; a new technology with acknowledged hazards and demonstrated advantages, but badly understood and beset by aggressive critics – hence concerned for the future. I have heard turn-of-the-century stories about demonstrators electrocuting dogs in New York's Central Park to protest the introduction of "dangerous" high-voltage alternating current, which to that point had been used to electrify convicted murderers, not homes and factories.

I doubt if in 1890 an "electric safety" equivalent of the AECB would have prevented D.C.-proponent Edison from losing the Niagara Falls hydroelectric development contract to A.C.-advocate George Westinghouse, but it might have saved a few of those poor dogs.

This is because an effective regulatory body – and one that is publicly perceived as such – contributes as much to the reputation of the industry it governs as it does to the industry's performance.

Just as people would refuse to fly if the air traffic control system fell into disrepute, so the Canadian public will balk at nuclear energy applications if the AECB is seen to be less than effective, or is not seen at all. In terms of public perception, if for no other reason, I believe the nuclear industry profits from a strong, visible regulator.

Accordingly, as we progress through the 90s, I would hope that the CNS, the CNA and their members will be supportive of the AECB's revitalization.

Despite what critics say, the AECB is not in the business of promoting nuclear energy. It does, however, have a job to do in promoting nuclear safety: to encourage safety in the workplace and with respect to the environment; and to tell Canadians how safety is achieved.

We have now been given the tools to do this job better. While I think it is fair to say the AECB has discharged its mandate quite well, and compares favourably with comparable bodies in other jurisdictions, changes are necessary so that the AECB can continue to serve the Canadian public with distinction in the future.

The challenges of the 90s will find the AECB prepared.

The Anti-Nuclear Game

Gordon H.E. Sims, University of Ottawa Press, 1990. ISBN 0-7766-0235-3

Reviewed by A.W.L. (Duke) Segel

Directed at 'the widest possible audience', this book is intended by the author to increase the level of acceptance of nuclear power by the public. The format he has chosen is to present the 'facts', then use them to expose the myths that the anti-nuclear establishment has created in its attempts to discredit nuclear power. To achieve his objective, he must communicate his message to those of the lay public who have accepted these myths as the whole truth. This requires that the book be written in a language and style the lay person can understand, that is, with a minimum of technical jargon and in human terms.

Gordon Sims has the credentials to write this text. He has a B.Sc. from the University of London, and an M.A. from Carleton University in Ottawa. In his 30-year professional career in the nuclear field he has worked for the (former) Radiochemical Division of Atomic Energy of Canada, the Atomic Energy Control Board and most recently was an assistant energy policy advisor to the Department of Energy, Mines and Resources from where he retired in 1989. He has published 'A History of the Atomic Energy Control Board' (Government of Canada, 1981).

The book is well organized. The ANTI-NUCLEAR GAME which he notes is a serious game, is explained first by introducing the major players who make up the anti-nuclear establishment, *viz*: Energy Probe, Canadian Coalition for Nuclear Responsibility, International Institute of Concern for Public Health, Greenpeace, etc., and then describing how the game is played "... by presenting ... inaccurate or misleading information ... to achieve ... the arousal of fear of nuclear power ... ." This introduction is followed by a series of chapters, each dealing with a facet of nuclear technology, *viz*: radiation, power reactors, waste, mining, proliferation, alternative energy sources, risks and finally benefits of nuclear energy. For each topic, Sims first presents 'The Facts' as currently understood and accepted by the scientific community, and then follows by quoting statements made by 'The Game' players, which generally he labels as either inaccurate or misleading, citing 'The Facts' to explain why. Anticipating that the lay reader might hesitate to accept the author's arguments because of his likely pro-nuclear bias, Sims closes with a chapter titled 'Who to Believe' in which he summarizes the findings, generally favourable, of several major public inquiries into the nuclear industry.

How well does the book achieve its purpose to communicate its pro-nuclear message to the lay public? In the main, the simplified technical explanations, likely comprehensible to the lay reader, are sufficient to make the point at hand. But because of the brevity associated with simplification, some repetition, particularly where major issues are being explained, would be welcome. For example, the important plutonium myth, the hot particle theory, is referred to several times; I had to search out and re-read the write-up (p. 59) each time to identify the mythology.

A few critical items could be accorded more complete descriptions; the simplified version in the main text could be supplemented by a fuller technical account offered in an appendix. For example, Sims makes the statement that a power reactor cannot explode like a nuclear bomb, a fear that many lay persons have; but no explanation as to why not is offered. Whether or not the lay reader can understand the technical jargon, that person is more likely to accept the statement as 'fact' if the explanation is at hand.

Sims does well explaining the concept of risk, and indeed addresses it more than once, presumably because he recognizes how important it is that the lay person understand. I did, however, feel uncomfortable with his averaging of consequences, a concept the mathematician can appreciate, but perhaps would not communicate well to the lay person. Does a statement such as "... the average death rate would be only .0001 per calendar year" (p. 114) have any meaning to the lay reader? Although the averaging of the consequences has mathematical significance, it is not the only way of putting the risk into perspective. It ignores the human reaction to the consequence; death involves 1, not 0.0001! Perhaps it would be more effective to limit the argument to make the point of the low risk by comparison to other risks in life as done by the UGNRO spokesman explaining the Sandia study cited, or by Bernard Cohen in the Loss of Life Expectancy table reproduced by Sims (Chap. 8) rather than averaging out the consequence.

A few of the arguments tabled by the author to destroy the anti-nuclear myths might come back to haunt him. As a case in point (p. 147), Sims counters the claim that "... the spent fuel from a nuclear power plant is ... more hazardous than the uranium going in" by noting that over the very long term the non-fissioned uranium atom is potentially very much more hazardous than the fissioned atom. Elsewhere (p. 135), though, he argues that because of their relatively long half-lives, the non-fissioned uranium atoms are relatively harmless. Both statements are accurate, but should the reader juxtapose them he might very well conclude that the author is claiming spent fuel is almost harmless, exposing Sims to the accusation that he is playing the same game as the anti-nuclear activists! Sims does deal with the issue of safe disposal and isolation of the hazardous waste products, but the integrated activity comparison comes across as a diversionary tactic, as though safe disposal and isolation are not really important anyway. Sims' write-up of this issue demonstrates the essence of the communications problem; to be accurate and not mislead, statements must be complete and properly qualified, but to put the message across they must be simple, brief and, if the next-to-impossible can be done, written so as to minimize the possibility of being quoted out-of-context. To be fair to Sims, he is most often successful in accomplishing the possible.

The author notes that a lack of general scientific knowledge is a characteristic of the average anti-nuclear activist.

There are though some prominent scientists who support the movement. The observant reader will ask, 'Why?' The question is neither put explicitly nor answered. Yet to this reviewer, it is important that it can be addressed. Left unanswered, the reader might very well doubt the completeness of the scientific facts as tabled in the text. Why indeed are there scientists who are anti-nuclear? Possibly the anti-nuclear scientist is that for other than technical reasons, for example, concern that business interests will sacrifice safety for economic return. Whatever the reason, it would have been better to have dealt with it. To his credit, Sims is not so completely enraptured by pro-nuclear dogma that he fails to give credit where it is due. He deals somewhat sympathetically with some aspects of the soft energy movement, leaving this reader with the impression that he recognizes that not all is black or white only. And he does allow at the end that there is a need for intelligent, honest criticism of the nuclear power industry, but not for a strident anti-nuclear movement playing games!

Does this book achieve what the author intended? That he has exposed and debunked many myths propagated by the anti-nuclear establishment, there can be little doubt. Whether or not he will have 'increased the level of acceptance of nuclear power by the public' depends on how well he has communicated with 'the widest possible audience' which I choose to interpret as the lay public. Sims has presented most of the story in a clear, easy-to-understand fashion which should cause the average lay reader who is tempted to read the book to question the anti-nuclear game closely. And if the book does not find a lay readership which would deny Sims a direct communication link to the public, the least he has accomplished is to provide the pro-nuclear advocate with clearly and simply stated arguments to counter the great majority of half-truths or inaccuracies played out in the anti-nuclear game.

But to exploit those arguments, the pro-nuclear advocate must learn one lesson from the anti-nuclear establishment, that is, to be able to respond to the 10-second inaccuracy with the 10-second accuracy. Despite Sims' valiant efforts, he has not accomplished that.

The BEIR V Report

Reviewed by D.K. Byers

Ed. Note: *A basic constraint in the design and operation of nuclear facilities is the need to minimize exposure to ionizing radiation. The risk factor associated with such exposure, i.e., the probability of harm (such as fatal cancer) from a unit exposure, has been under continual review over the last several decades. The major source of data comes from on-going studies of the survivors of the Hiroshima and Nagasaki atomic bombs of 1945.*

The most recent authoritative study was conducted by the Committee on the Biological Effects of Ionizing Radiation (BEIR) of the U.S. National Academy of Science and published earlier this year as the fifth major report of that committee – hence the nomenclature "BEIR V".

The following is a slightly edited version of a review printed originally in a recent issue of the Bulletin of the Canadian Radiation Protection Association. It is reproduced here through the kind permission of Chris Pomroy, editor of the CPRA Bulletin and of Dr. David Myers, the author, who recently retired from AECL Research Company.

The BEIR V report on "Health Effects of Exposure to Low Levels of Ionizing Radiation" (421 pages) became available from the National Academy Press, Washington, early in January 1990. Following the 1988 UNSCEAR (United Nations Scientific Committee on the Effects of Atomic Radiation) report, BEIR V is the second major report by a scientific committee that provides new estimates of the potential risk of radiation-induced cancer. These new estimates are based largely on revised data for the Hiroshima-Nagasaki survivors. Both of these committee reports are concerned mainly with effects of exposure to X and gamma rays; risks from exposure to alpha emitters were considered separately in the 1988 BEIR IV report.

Estimates of the lifetime risk of fatal cancer following exposure to gamma rays at high dose rate are very similar in the 1988 UNSCEAR and 1990 BEIR reports (Table 1). Since most of the Hiroshima-Nagasaki survivors were still alive at the end of the last follow-up in 1985, it is necessary to use various risk projection models to extrapolate from observed excess cancers to date to predicted values that might be expected over a total lifetime. The UNSCEAR analysis used simple "absolute" and "relative" risk projection models. BEIR V used a modified relative risk model, in which the per cent increase in normal risk of developing cancer varies with age at exposure and with time since exposure to radiation. The resulting estimates for effects at high dose rate are within the range proposed in the 1988 UNSCEAR report (Table 1). Predicted lifetime risks are tentatively higher for children than for adults, but are about the same for males and for females.

The predicted lifetime cancer risks at high doses of gamma radiation at high dose rate (Table 1) are, in general, appreciably higher than those predicted by the same committees in previous years. Both the BEIR V committee and the 1988 UNSCEAR report were cautious in extrapolating from these numbers to predicting the potential but non-measurable effects of low doses at low dose rate. The UNSCEAR report suggested that potential risks at low doses and low dose-rates would be 2 to 10 times lower. The summary of BEIR V indicated that "for low LET radiation, accumulation of the same dose over weeks or months, however, is expected to reduce the lifetime risk appreciably, possibly by a factor of 2 or more". Risk estimates for leukemia were based on a linear-quadratic

Table 1. Estimates of the potential lifetime risk of radiation-induced fatal cancer (cases per Gray)

	Total population ($\times 10^{-2}$)	Working population ($\times 10^{-2}$)
High dose rate:		
UNSCEAR 1988	4 – 11	4 – 8
BEIR 1990*	9	7
Low dose rate:		
UNSCEAR 1988	0.4 – 5.5	0.4 – 4
BEIR 1990*	2.3 – 4.4	1.9 – 3.5
ICRP 1977	1.25	1.25

* the leukemia risk at high dose rate is twice that at low dose rate

dose-response model, as in the 1980 BEIR III report, and thus contain an implicit dose-rate effectiveness factor (page 174 in BEIR V). The text on page 23 of BEIR V suggests that a dose rate effectiveness factor of 4 to 5 should be considered for the induction of solid cancers by low LET radiation at high compared to low dose rate. Risk estimates derived from BEIR V (Table 1) for low LET radiation at low dose rate were therefore calculated on the basis of dose-rate effectiveness factors of 2 to 5 for solid cancers. The resultant estimates of potential risk from low LET radiation at low dose rates are summarized in Table 1; the values adopted by the ICRP (International Commission on Radiological Protection) in 1977 are given in the same table for comparison.

The BEIR V risk estimates for leukemia alone (excluding solid cancers) are 4 to 5 times higher than the value suggested by the ICRP in 1977, and twice as high at 1 Gy delivered at high dose rate as the value given in the 1988 UNSCEAR report. There are thus appreciable uncertainties in these estimates; these uncertainties are further emphasized by the negative values in the recent report on U.S. radiation workers by Gilbert *et al.* in **Radiation Research**, v. 120, pp. 19-35 1989.

One table on page 176 of BEIR V is misleading, since it compares BEIR III cancer risk estimates at low dose rates with those from BEIR V at high dose rate; this error is not repeated in the executive summary. An unusual feature of the BEIR V report is that it does not allow for the possibility of reduced effects at low doses, as distinct from low dose rate. Assuming a linear, non-threshold dose-response relationship, this would mean that fatal cancer risks from 1 mSv of medical X-rays delivered at the usual high dose rate could be considered equivalent to those from 2 to 4 mSv of low LET radiation accumulated at low dose rate over a period of weeks or months. The BEIR V report did not discuss the implications of this concept for radiation protection purposes.

The BEIR V report, like a recent paper from the American Medical Association (**JAMA**, 17 November 1989) does not exclude the possibility of zero risk at very low doses and low dose rates. It remains to be seen how conservatively these new risk estimates will be interpreted by regulatory agencies. Under the currently accepted principles used in radiation protection, any change in estimates of risk of fatal cancer for low doses of low LET radiation would automatically change estimates of the risks from high LET radiation unless the quality factors for high LET radiations were changed at the same time; this would require careful re-examination of epidemiological data on radium, radon progeny and other alpha emitters. Although there are some differences in detail, the overall genetic risk estimates in BEIR V are similar to those given in the UNSCEAR reports from 1977 to 1988. Data on induction of severe mental retardation after irradiation *in utero* are also similar to those published by the ICRP and by UNSCEAR in 1986.

The BEIR V report also provides an excellent summary of scientific principles involved in risk assessment, mechanisms of radiation-induced cancer, and of other somatic and fetal effects of exposure to radiation. The compact overview presented in BEIR V will undoubtedly prove valuable to many people. Another pleasant feature of the BEIR V report is that it is well written and easy to read.

CNS News

Members honoured

Two CNS members received awards from the Canadian Nuclear Association at the joint CNA/CNS Conference held in Toronto in June.

Dr. Dan Meneley, professor of nuclear engineering at the University of New Brunswick, was awarded the prestigious W.B. Lewis Medal. This medal, named after W.B. Lewis, long-time head of research at AECL, honours a Canadian scientist or engineer who has made a significant technical contribution.

The award recognized Dr. Meneley's contributions in nuclear physics, kinetics and fuel cycles and particularly his work on the safety of CANDU nuclear power plants. The citation noted that while with Ontario Hydro Dr. Meneley built up the nuclear analysis team responsible for the licensing of all Ontario Hydro nuclear stations. He also was one of the leaders in developing the Canadian nuclear safety R and D program.

Dr. Donald Hurst received an Outstanding Contribution Award in recognition of his contributions to nuclear science, engineering and regulation.

Dr. Hurst, now retired, began his association with the nuclear program at the Montreal Laboratory during World War II. He held several senior posts at CRNL over a period of 25 years, was head of the Division of Nuclear Reactors and Power at the IAEA in the mid 1960s and president of the AECB from 1970 to 1974. Following his retirement he was chairman of the Senior Advisory Group for the IAEA nuclear safety standards (NUSS) program for several years.

1990 CNS Conference Co-chairmen Nabila Yousef and Ben Roubin pose with outgoing president Eva Rosinger.

In memory

Dear Colleague:

We are all deeply saddened by the tragic loss of our good friend and colleague Ladislav Boruvka who was drowned in May.

Ladislav had a long-standing relationship with the Canadian nuclear industry, having dealt extensively at one time or another with AECL, AECB, ANSL, Ontario Hydro, Hydro Quebec and New Brunswick Power. Over the course of the years, Ladislav made several important contributions in the fields of thermalhydraulic analysis and numerical modelling. He was a particularly intelligent and caring man who firmly believed in doing things right and in the most efficient manner. He took great pride in accepting the challenge that complicated tasks had to offer, and showed particular enthusiasm in applying new ideas and unconventional methods to achieve a better result. It was these characteristics that earned Ladislav the high degree of respect that he held amongst both the technical and academic communities.

Outside of work, Ladislav's primary love of life was for his wife and five beautiful daughters, for whom he cared very deeply. Unfortunately, he did not leave behind adequate provision for his family, and this has thus become the second tragedy. It is for this reason that a number of his close friends are organizing a fund raising drive aimed at obtaining both individual as well as corporate contributions. We would therefore greatly appreciate it if you would please make a contribution to the family, as well as discuss the issue with both your colleagues and your corporation.

If you are interested in helping the family of one of our colleagues, please contact one of the following individuals.

Thank you for your generosity,

M. Collins / P.D. Thompson

Contacts:

Samir Girgis, AECL-CANDU	(416) 823-9040 (W)
Sunil Nijhawan, Ontario Hydro	(416) 592-4008 (W)
	(416) 783-5227 (H)
P.D. Thompson, N.B. Power	(506) 659-2220 (W)
	(506) 738-8901 (H)
C.K. Scott, Atlantic Nuclear	(506) 458-9552 (W)
	(506) 458-9426 (H)
Andre Baudouin, Hydro Quebec	(514) 340-4290 (W)
Dave Richardson, WNRE	(204) 753-2311 (W)

Calendar

1st Internation ' Topical Conference on Neutron Radiography Sy .em Design and Characterization
Sponsored by CNS, to be held **August 28-30, 1990** in Pembroke, Ontario. For information contact: **A. Lane**, (613) 584-3311.

International Conference on Handling Hazardous Materials: Social Aspects of Facility Planning and Management
Sponsored by CNS et al, to be held **September 30-October 3, 1990** in Toronto, Ontario. For information contact: **G. Leitch**, (204) 753-2311.

International Meeting on the Safety, Status and Future of Non-Commercial Reactors and Irradiation Facilities
Sponsored by CNS et al, to be held **September 30-October 4, 1990** in Boise, Idaho. For information contact: **D. Croucher**, (208) 526-9804.

International Conference on Containment Design and Operation
Sponsored by CNS, to be held **October 14-17, 1990** in Toronto, Ontario. For information contact: **P. Burroughs**, (416) 592-5210.

CNA/CNS Students Conference
Sponsored by CNS, to be held **March 22-23, 1991** in Kingston, Ontario. For information contact: **H.W. Bonin**, (613) 541-6613.

2nd International Conference on Methods and Applications of Radioanalytical Chemistry
Sponsored by CNS et al, to be held **April 21-27, 1991** in Kona, Hawaii. For information contact: **R. Jervis**, (416) 976-7129.

International Topical Meeting on Mathematics, Computations and Reactor Physics
Sponsored by CNS et al, to be held **April 28-May 1, 1991** in Pittsburgh, Pennsylvania. For information contact: **M. Milgram**, (613) 584-3311.

1st International Conference on CANDU Fuel Handling Technology
Sponsored by CNS, to be held **May 7-8, 1991** in Toronto, Ontario. For information contact: **A.C. Welch**,

CNA/CNS Annual Conference
Sponsored by CNS, to be held **June 9-12, 1991** in Saskatoon, Saskatchewan. For information contact: **D. Malcolm**, (306) 665-6874, or **A. Wight**, (416) 592-5210.

6th International Conference on Emerging Nuclear Energy Systems
Sponsored by CNS et al, to be held **June 17-21, 1991** in Monterey, California. For information contact: **A.A. Harms**, (416) 525-9140 ext. 4545.

International Safety and Thermal Reactor Conference
Sponsored by CNS et al, to be held **July 21-25, 1991** in Portland, Oregon. For information contact: **W. Munn**, (503) 376-4953

15th Topical Meeting on Reactor Operating Experience

Sponsored by CNS et al, to be held **August 11-14, 1991** in Seattle, Washington. For information contact: **K.M. Tominey**

16th CNS Symposium on Simulation of Reactor Dynamics and Plant Control

Sponsored by CNS, to be held **August 25-27, 1991** in Saint John, New Brunswick. For information contact: **P. Thompson**, (506) 659-2220.

4th Topical Meeting on Tritium Technology in Fission, Fusion and Isotopic Applications

Sponsored by CNS, to be held **September 30-October 4, 1991** in Albuquerque, New Mexico. For information contact: **W.J. Holtslander**, (613) 584-3311.

3rd Joint International Waste Management Conference

Sponsored by CNS, to be held **October 21-26, 1991** in Seoul, South Korea. For information contact: **L.C. Oyen**, (312) 269-6750.

In-coming president Hugues Bonin presents a gift to retiring president Eva Rosinger.

The CNS *Bulletin* needs:

- news of branches and members
- views and opinions
- information of technical programs
- concise technical papers

Send your material to the CNS office or directly to the editor:

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9 Sandwell Cres.,
Kanata, ON K2K 1V2.
Tel.: (613) 592-2256, FAX (613) 820-3593

Darlington's Seventh Generation Monument

The Canadian Nuclear Society was intrigued to receive an invitation last summer from the Nuclear Awareness Project of Oshawa to contribute a statement for a time capsule it was preparing to seal inside a monument to be erected to mark the start-up of the Darlington Nuclear Generating Station in Ontario. The Awareness Project had invited a spectrum of organizations and individuals with an interest in nuclear and social issues to provide one page statements to "present a complete perspective on the nuclear debate".

The theme of the modest fieldstone monument, erected on the South Service Road at the entrance to the station, is expressed in its bronze plaque, which reads:

"In our every deliberation, we must consider the impact of our decisions on the next seven generations." *from the Great Law of the Haudenosaunee (Six Nations Iroquois Confederacy)*

This monument marks the opening of the Darlington Nuclear Generating Station. We do not inherit the earth from our ancestors – we borrow it from our children. The time capsule contained herein shall be opened after seven generations, in the year 2129. The capsule contains information reflecting the debate on nuclear technology. Our children shall judge us.

Nuclear Awareness Project, 1989

The CNS Council welcomed this invitation to engage in a dialogue with a group with whom we have experienced only adversarial relations to date, and at the same time to address our descendants on a subject dear to our hearts. Along with Energy Probe, Ontario Hydro, Greenpeace, AECL, the Town of Newcastle, CNA, Ralph Torrie, F. Kenneth Hare and several others, we set pen to paper to express our raison d'etre. After much massaging of words and exchanges of faxes, agreement was reached on the text set out in English and in French (see below).

Whether our descendants will be greatly enlightened by what they read in 2129 is a little difficult to say. We may be so bold as to assume that by then the "nuclear debate" will be over, much as the great "inoculation debate" of the 1920's and the "fluoridation debate" of the 1960's seem to have died down somewhat.

Rosalie Bertell and others of the International Institute of Concern for Public Health encapsulated a retrospective that:

"It was and is our conviction that this plant released radioactivity at a level likely to harm you and to harm the earth. We tried to get "permissible" levels lowered, and slowly, (too slowly) this is happening.

We tried to provide a watching government which would document health and raise an alarm at the first sign of trouble. That too may be happening. If all this fails – please know that we are sorry. We loved you who are yet unborn, and we cared."

Energy Probe laments that: "Our leaders have shown utter disregard for the welfare of future generations. We pray that this madness will end . . . We apologize for the myopia of our leaders."

Greenpeace wrote (on recycled paper) that: "The damaged

shoreline of Lake Ontario on which you find this message may be by your day a sacrifice area, a no-humans land, a scrap of the earth upon which no one and no thing will grow."

Ralph Torrie recycled his submission to the 1977 Ontario Royal Commission on Electric Power Planning which compares the Darlington plant to "building a bridge toward the open sea." He judges nuclear power to be "irrelevant", "poor, slow, expensive", "ethically unsound" and "inequitable". Unfortunately, we are not told why it is these things.

The Atomic Energy Control Board advised our descendants of the names of its members presently responsible for Darlington licensing decisions and the number of metres of shelf space taken up by the bound volumes of its review and analysis (25, if you must know).

Atomic Energy of Canada Limited's chairman, Marnie Paiken told her readers that "five of the top ten large reactors in the world are CANDUs" and pointed out that "We have found no magic way of producing energy, and no source of energy is without risk."

The Canadian Nuclear Association calculates that "an average Ontario worker takes only 15 seconds to earn enough money to purchase more electricity than could be generated in a full day of continuous physical effort." The CNA adjures our descendants: "May you find that we were not wanting in our vision nor our duty as we helped to create your world."

Ontario Hydro's chairman Robert Franklin expressed faith in the safety, economy and reliability of fission power, while wishing his audience blessed by "... totally clean, totally renewable, non-polluting energy."

Our CNS Past President Eva Rosinger expressed in her letter to Irene Kock, Executive Director of the Nuclear Awareness Project, her hope that the contributed statements would help to demonstrate a common concern for the husbandry of our planet. The concern is common, but, judging from the texts offered, some have more fear than hope.

The time capsule was sealed in the cairn on 1989 October 11, at 11 a.m. It evoked little publicity, despite some advance work by its sponsors. What our descendants will make of its messages 140 years hence is debatable; the sociologists will doubtless find it of more interest than the politicians by then. Just as Alexander the Great, who was assured by the Delphic Oracle before his battle with the Persians that there was "a great victory" in the offing (unfortunately omitting to say *whose* victory), can we all relax, secure in the knowledge that history will judge us correctly?

(Text of message, English)

"In our every deliberation, we must consider the impact of our decisions on the next seven generations."

We, of the Canadian Nuclear Society, greet you, the grandchildren of our grandchildren's grandchildren, and humbly submit for your judgment our lives' work. We address you as scientists and engineers who chose as our vocations the increased understanding of our universe in all its beauty and majesty and the creation, based on that understanding, of the means for all of our human family to achieve fulfilment of its ancient quest for freedom from want, in harmony with our mother Earth and with each other.

We, of the first generation to view our small and precious planet from outer space, have been privileged to participate as pioneers in harnessing nature's most fundamental energy source, which returns matter to the energy from which it came at the birth of our universe, and which has been the source of the energy that has made life on Earth possible.

This 3,600,000 kilowatt nuclear generating station utilizes a closed cycle technology, which displaces the large scale production of chemical combustion wastes and their dissipation into the biosphere. While the station has been designed to last 40 years, we are confident that electricity will still be in production on this site by nuclear fission or fusion on the day you open this capsule in 2129. Between now and then, continued operation of a nuclear station of this size will have avoided the combustion of over one and a half billion tons of coal, which would have poured four billion tons of carbon dioxide and untold millions of tons of acid gases into the atmosphere, and 100 million tons of ash onto the surface of our land. We are confident that the wastes from the less than 25,000 cubic metres of nuclear fuel used by 2129 in this station will be securely isolated from the biosphere in a permanent repository beneath both natural and engineered barriers and will not disturb your enjoyment of this beautiful land we have shared.

Our industry will be the first in human history to provide for the permanent disposal of its wastes so that they will not burden you, our children. We believe that our knowledge and skills in managing nuclear wastes can and will be applied to managing wastes from other human activities.

We, the men and women of the Canadian Nuclear Society, are proud of the modest contribution to the heritage of humankind's knowledge represented by our part in developing and implementing the Darlington Nuclear Generating Station. We dedicate our efforts to you, our children, from whom we have borrowed this Earth for a short time. May you enjoy the fruits of our labour and build upon and improve them for your own sake and that of your children.

1989 October 11

(Text of message, French)

"Dans toutes nos délibérations, nous nous devons de considérer l'impact de nos décisions sur les sept générations qui nous suivent."

Nous, de la Société Nucléaire Canadienne, transmettons nos salutations à vous, les arrières-arrières-petits enfants de nos petits-enfants, et, humblement, nous soumettons le travail de nos vies à votre bon jugement. Nous nous adressons à vous en tant que scientifiques et ingénieurs qui avons choisi comme vocation la connaissance accrue de notre Univers dans toute sa beauté et sa majesté et la création, basée sur cette connaissance, des moyens pour notre famille humaine de s'affranchir du besoin, en harmonie avec notre Mère la Terre et avec chacun d'entre nous.

Nous, de cette première génération à avoir contemplé notre petite et précieuse planète à partir de l'Espace, avons eu le privilège de participer comme pionniers au harnachement de l'énergie de la plus fondamentale de la nature par un phénomène qui retourne la matière à l'énergie dont elle fut créée à la naissance de l'Univers, et qui a été la source de la Vie sur la Terre.

Cette centrale nucléaire de 3 600 000 kilowatt utilise une technologie à cycle énergetique fermé, qui prévient la combustion intensive de matières chimiques et la dispersion subséquente d'abondants et de dangereux résidus de cette combustion dans la biosphère. Bien que cette centrale nucléaire ait été conçue pour une durée de 40 ans, nous sommes confiants que l'on continuera à produire de l'électricité en cet endroit soit par la fusion nucléaire, le jour où vous ouvrirez cette capsule en l'an 2129. Dans l'intervalle de temps entre aujourd'hui et ce jour-là, l'exploitation continuelle d'une centrale nucléaire de cette taille aura permis d'éviter la combustion de plus d'un milliard et demi de tonnes de charbon, qui aurait déversé quatre milliards de tonnes de bioxyde de carbon et plusieurs millions de tonnes de gaz acides l'atmosphère, en plus de produire 100 millions de tonnes de cendres sur le sol. Nous sommes convaincus que les déchets de moins de 25 000 mètres cubes de combustible nucléaire utilisé jusqu'en 2129 dans cette centrale seront isolés de façon sre de la biosphère par des barrières naturelles et conçues par l'homme et cela dans des sites permanents afin de ne pas mettre en péril votre jouissance de cette merveilleuse Terre que nous partageons.

Nous sommes fiers de ce que notre industrie ait été la première de l'histoire de l'humanité à se préoccuper activement de la disposition ultime de ses déchets afin de ne pas encombrer les générations futures. Nous croyons que les connaissances et l'expertise que nous avons acquises en matière de gestion des déchets radioactifs peuvent et pourront être appliquées à réaliser les mêmes objectifs pour d'autres activités humaines.

Nous, les hommes et les femmes de la Société Nucléaire Canadienne, sommes fiers de notre modeste contribution à la somme des connaissances de l'humanité, mise en évidence ici même par la mise en oeuvre de la Centrale Nucléaire de Darlington. C'est à vous que nous vous avons emprunté cette Terre pour un court laps de temps. Puissiez-vous jouir des fruits de nos labours, et les améliorer pour votre bonheur et celui de vos enfants.

11 octobre 1989

The Unfashionable Side

Tunes of Glory

It is indeed an honour and a pleasure for me to appear in this august column and I am very grateful indeed for the opportunity. Though I am not glad, of course, that my good friends Ernest Worthing and George Bauer are unable to appear owing to other matters currently dominating their attention. Anyway, I shall tell you how this came about.

I am sitting in in my office at the Bruce one morning, when in comes my boss. Naturally I am more than somewhat perturbed by his sudden appearance since I figure that he has just read my quarterly report and has not found it entertaining and as a consequence of this has come to express himself violently to me about it. But it turns out this is not the case, because he says in a mild bellow: "Quentin, I want you to attend this water chemistry conference next week at Aphasia University." Naturally I am very delighted by this since it will give me an opportunity to see my old friends Ernest and George again and perhaps nibble on a few drinks with them, and I am highly honoured too that my boss has selected me to represent Bruce Operations at this big technical wing-ding.

On the day before I leave my boss calls me into his office. "Quentin" he says, "we rely upon you to uphold the honour of the station at this conference". Of course I explain that this will be my continuing concern, and he need have no fears on this matter, but he continues, "and I trust you will not disgrace our reputation by any display of drunken or libidious behaviour, because any report of such displays would disturb me deeply and might give me cause to give someone a bust on the beezer". I am quite sure when he says this that it is probably my beezer that he has in mind for busting and that he is too tactful to say so directly, so I again reassure him of my devotion to sobriety and continence and get on my way before he can change his mind.

When I get to Aphasia I register and check out the old accommodation which I find more than somewhat depressing since we are to be sleeping in student residences, the students all being away on vacation or in jail or somewhere. Actually they are probably better off in jail since our local hoosegow in Calandria Corners is much more spacious and luxurious than these narrow cells. When I get down to the reception in the faculty club things seem to have become a bit more cheery as free drinks are being supplied, though this does seem to upset the gloomy looking geezer behind the bar. It is easy to tell who is who since all the guys from head office are wearing 900 dollar suits and carrying leather portfolios with brass corners while the guys from the station are wearing polyester suits and harrassed expressions. I am quite surprised to see a bunch of very scruffy panhandlers crowded up to the bar and I begin to wonder who let them in when one turns round and I see it is Ernest Worthing, and I realise that these are in fact the profs who have come for the free drinks, which only goes to show that whatever

anybody says, profs know a thing or two.

Ernest comes over and gives me the big hello and asks me how I am enjoying the conference so far and so I explain to him that I am very much enjoying the free drinks but that I do not know that I will sleep very well and is there a local hoosegow I could go to instead. "My dear fellow", Ernest says, "by no means. You must stay at my place. The accommodations here are suitable only for undergraduates – I wouldn't keep my pigeons in 'em!".

In very short order he has me put into a cab with my bag, and delivered to his house. I know it must be his because the hackie refuses to go further than the top of the street and the houses on either side are empty and have weatherbeaten "for sale" signs. Also there's Worthing's huge jalopy sitting dripping oil onto the driveway.

In no time I am unpacked and back to the faculty club where things have livened up a bit. George Bauer is with someone who it is not safe in these feminist day to describe as a stunner but who he introduces as Sally from the Philosophy Department who is by no means a platonist. She is wearing a necklace with big rocks in it and Bauer borrows my pencil chamber to check these stones for alpha radiation. I am puzzled by this since I am sure Bauer knows that this is not what pencil chambers are used for.

Earnest Worthing is with two beers one of which he gives to me and I explain to him that because of the honour of the station I have promised my supervisor to drink only a moderate amount. To my surprise he is very approving. "There is too much heavy drinking going on in these degenerate times", he says, "and I myself have given it up completely – this evening I drink only root beer and, perhaps later some apple juice". To me this news is surprising – but I notice later that Worthing's root beer comes out of a pump labelled "Arkell Best Bitter."

About two hours later I am beginning to think it is time to go home. George Bauer is lying on a sofa with Sally from the philosophy department who is by no means a platonist and he is undoubtedly still checking activity levels but it is difficult to see whether he is using my pencil chamber. Ernest has now started drinking apple juice though it is a mystery to me why he keeps it in an old brandy bottle – and indeed, why he insists on pouring some of it in the piano. A couple of the head office types are trying to get their lap top computers to work but I think to myself that they may well not be successful in this since I see Ernest spill some of his root beer into the machines some time earlier.

Leaving all this excitement with some regret I get a cab back to Ernest's place, and very soon I am in bed and pounding the ear. All of a sudden I am woken by a loud rumbling noise which seems to come from the street. I go to the window and look out but see nothing, although the rumbling noise is louder and as well I can hear music. All of a sudden around the corner of the street comes this grand piano and I see that it is being pushed by Ernest at a very healthy speed indeed, while George sits on the lid and plays with his feet. Ernest takes the corner a little wide and the piano bounces off a lamp-post with a great crash and comes to a halt. George falls off the piano in the key of G. "I told you to lean into the curve" shouts Ernest.

"Never mind about that" shouts George back, "give her a swing and don't forget to advance the timing".

So engrossed are they in their conversation that they do not hear the siren or see the flashing lights until the prowl car comes round the corner and screeches to a halt. I am feeling bad about not warning them, but I remember what my boss says about upholding the honour of the station and it is very clear to me that getting involved in some kind of barney with the local cops is not a good way to do this. A big fat sergeant leaps out of the car along with two other cops.

"Worthing! Bauer!" he shouts, "you are under arrest! Mattingley! get that piano. It's evidence".

"You tell Mattingley to leave that piano alone, Spineways!" shouts George, and dives at the sergeant and starts chewing at his ankle. Ernest skips over to where his jalopy is parked and my first idea is that he is going to hightail it out of there and I am quite disgusted at his pusallinimous conduct. But then I see that this is far from his mind, for he reaches in his car and comes out with a soda syphon, spins round, and opens fire with it at the sergeant. I am full of admiration at his technique and his accuracy and I think that if ever again Louie the Lug asks me who to recommend for chopper duty I will suggest Ernest. He fires in short bursts. The first burst hits Spineways slap between the eyes and he lets out a loud shout of protest. This leaves his mouth open so Ernest directs his next burst there, and again is right on the button. The next two bursts take him in the left ear and then in the mouth again.

But by this time the other coppers have stopped laughing enough to bundle Ernest and George into the cruiser and anyway I think that by then Ernest runs out of ammunition.

After the cruiser takes off I am feeling quite regretful because I am sure that both my good friends Ernest and George will be in for a very tough time indeed down at the local hoosegow. If the expression on the sergeant's face is anything to go by, then it is unlikely that I will be seeing them this side of the year 2020. It is with this sad thought in mind that I go to sleep – only to be wakened by the telephone. I pick it up and it is none other than Ernest. After some hello-ing I ask him if he wants me to call his lawyer. "Thank you, Vernon, I need no lawyer at the present time" he says "but I do need you. Will you please come down to the local police headquarters at once".

Now this request disturbs me more than somewhat. I explain to Ernest that I have assured my boss that I will do nothing to bring the honour of the station into disrepute which means I must avoid drunken or libidinous behaviour and eschew unseemly pranks. "It is possible" I further explain to Ernest, "that my boss might interpret my visit to you at the hoosegow as an unseemly prank and this might provoke him to an outburst of beezer busting, an eventuality I am very anxious to avoid".

"Now listen carefully, Vernon" says Ernest, "if you do not this minute come to visit me at the hoosegow I shall begin to entertain serious concerns about your health. I shall worry that you might have broken a leg. Or even both legs" he adds. "This would mean I would get worried enough to ask Big Al to check on your health". When I hear this I immediately assure Ernest that I am in perfect health and am leaving that instant and, moreover, there is absolutely no need to disturb Big Al of whom I have heard that he is a very tough customer indeed and does not like to be disturbed.

I arrive at the hoosegow and there after waiting for twenty

minutes I am ushered into a small room where Ernest is waiting. "Where is George?" I ask him.

"George was feeling very tired", Ernest explains, "and so the poor fellow is getting some rest at the moment".

Actually I can hear George resting quite clearly and he has already reached the verse about the vicar's daughter. I tell Ernest how much I admired his aim with the soda syphon and ask him where he learned to shoot like that. "In the RAF" he explains.

"Did you shoot at Bisley?" I ask him, thinking to keep the conversation on safe topics.

"I shot at everything" he says, "but enough of this idle chit chat. I need you to complete a task that is absolutely essential if a gross miscarriage of justice is to be prevented".

Naturally I enquire of him what gross miscarriage of justice he has in mind, but he just glares at me, then goes on to explain that I must obtain from his car a reel of the yellow warning tape we use at the station to indicate areas of radioactive contamination, as well as some of the warning notices. And I must then fence off the piano with the tape and chalk "gamma field 500 mR/h" on the warning boards. Naturally I protest that this seems mnisleading and possibly even dishonest and might be construed as an unseemly prank, especially as the piano isn't radioactive at all.

"Are you sure of that Vernon?" Ernest asks me, "and before you answer let me remind you that I am still very concerned about your health".

Upon reflection it does occur to me that I have no way of knowing that the piano is not indeed contaminated and this being the case carrying out Ernest's suggestion might be a prudent move, though of course I explain that the 500 mR/h seems a little high. "Make it 250 if you like" Ernest says generously, and waves me out of the door.

It does not take me too long to fix up the piano, and a most alarming sight it is when I have finished. I then finally get to sleep, and sleep in so late that I miss the first half of the morning sessions at the conference.

But it turns out that perhaps I do not miss too much if they are anything like the second half. First the guy from France gets up and says that everything in the water chemistry line in France is going very well. Then a guy from the US says that everything in the water chemistry line is absolutely excellent though he is concerned about the regulatory process. Then a guy from Germany says that the water chemistry business in Germany is pretty *ausgezeichnet* but there are problems with public acceptance. And our own Director of Operations says that the water chemistry in Canada is perfectly splendid and what's more we have a unique reactor system that uses pressure tubes and natural uranium. The guy from Britain doesn't say anything. With everything going so well, I am puzzled that we need a water chemistry conference.

It is not until the evening that I run into Ernest again, looking very pleased with himself. I am quite amazed that he is not starting on a forty-five year stretch on account of squirting a police sergeant with a soda syphon in a manner calculated to lead to a breach of the peace. But he explains the whole thing was a misunderstanding. "We pointed out that Bauer had discovered serious levels of radioactive contamination on the piano and had taken steps to have it isolated. What was misinterpreted as an attack upon former sergeant Spineways was in fact a successful personal decontamination operation, using the only available means – that is to say my gasogene. It was certainly highly successful", Ernest adds, "because after the operation no trace of contamination was found on the officer. I am thinking of offering the system to Operations".

"But what happened to the piano?" I ask him. Ernest explains that it is being transported to the Bruce Radioactive Waste Management Facility where it will be stored. "Bauer will be going up every week or so to play it, though he may find the plastic suit a bit of an encumbrance".

I am naturally very delighted for George, for I know how much he enjoys playing the piano, but I am very sorry for Ernest for he will get no chance to do so because since his last visit to the site the Station Manager has given the security guards "shoot to kill" orders, should he appear*.

"I do not mind, really" says Ernest, "I am not an enthusiastic piano player". And he smiles and adds, "and neither is Sally from the philosophy department who is by no means a platonist".

Quentin Vernon

* see *A Capital Approach to Regulation* (Vol. 10, No. 2, 1989)

(Ed. Note: Quentin Vernon *is a nom-de-plume of a long-standing member of the CNS)*

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