CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

Fall / L'automne 1990 Vol. 11, No. 3

IN THIS ISSUE:

- A Special Conference Report
  – *the 2nd International Conference on Containment Design & Operation*
- FEARO meetings
  – *on the nuclear fuel waste disposal concept*
- CNS activities

Contents

In this issue

A significant part of this issue is devoted to containment, specifically the Second International Conference on Containment Design and Operation, sponsored by the CNS and held in Toronto in October. Included is an overview by David Mosey and summaries of most of the sessions prepared by the session chairmen. We have also published the "as presented" version of the IAEA paper which gives a good international picture of the state of "containments" around the world (although certain "non-containments" were excluded), and the introductory remarks of Ontario Hydro's Bill Morison. Unfortunately Dr. Kenneth Hare, in his luncheon address, spoke only from rough notes. Dr. Hare referred to the "greenhouse" problem, noting that the immense amount of CO_2 produced from the burning of fossil fuels is creating a "containment" for the earth's atmosphere which will play havoc with our environment.

The other major issue covered in this issue is the review by the Federal Environmental Assessment and Review Office of AECL's deep geological waste disposal concept. It is encouraging that members from four branches made presentations to the first round of hearings, some of which are reproduced in this issue.

Your comments are always welcome.

CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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

A Time of Challenge

Just as we were putting this issue of the *Bulletin* "to bed" along came the Throne Speech of the new Ontario legislature.

The position of the new NDP government on nuclear power should not come as a surprise. In fact it could have been worse. At least Darlington will be completed whereas in some other countries, Austria for example, fully completed plants have been put in mothballs. The full meaning of the "moratorium" and its impact on the nuclear industry will not be clear for some time. Nevertheless, as members of a threatened profession we must recognize that the immediate future is not promising.

For the longer term, it is heartening that the hearings on Ontario Hydro's demand and supply study will continue. At least this provides time for everyone to consider carefully the electrical energy needs of the province and, hopefully, to recognize the very limited number of REAL options available.

One can be skeptical about the expected savings from conservation, even with Ontario Hydro forced into leading the campaign. Given the nature of our economy and society it is unlikely that demand can be reduced by much more than 25 per cent. With a demand growth rate of 4 per cent per year, as was the case for most of the 1980s, the savings would only offset 6 years of growth. If the growth rate ever recovered to the average of the previous five or six decades – between 6 and 7 per cent per year – the effect of possible savings will be even shorter.

This is a time of challenge for members of the Society. It is essential that anti-nuclear extremists not be allowed to portray themselves as the only "environmentalists". In fact their blind objection to things "nuclear" as a matter of faith (reminiscent of the reaction to some religious groups to certain authors) leads these extremists to advocate moves which will be truly damaging to the environment. Do we really want every small river dammed? Is it really likely that co-generation will lead to less pollution?

Members must speak out as concerned individuals. The CNA, as the spokesman of the industry has, like most business and political institutions, little credibility with the public. The CNS Council can prepare submissions and briefs but cannot speak for all members. In any event, our name puts us, in the eyes of the public, in bed with the CNA and the industry.

There is still time to make a submission to the Ontario Hydro demand/supply hearings. Several dozen good individual presentations, pointing out the need for electricity and the appropriateness of nuclear as a generation option, could have a significant effect on the Board's deliberations.

For our part we intend to provide, in the next issues, some good background material you can use in your arguments.

Accolades to the Organizers

This issue highlights the very successful containment conference held in October.

Having attended, over the years, a large number of conferences, symposia, and whatever, I am continually impressed with the quality of meetings organized by the CNS – or, more correctly, by CNS member volunteers. The organization is almost always meticulous, the technical content at a very high level, and that intangible "atmosphere", usually exhilarating.

All of us owe a great deal to those who have been the key players in the many meetings organized under the CNS banner. Not only have they provided stimulating technical fora for the exchange of information, they have enhanced the reputation of the CNS internationally, and, as a mundane but not insignificant fact, have built up the financial foundation of the Society.

For the Second International Conference on Containment Design and Operation special accolades should go to Paul Burroughs, Duane Pendergast and all of the committee members and helpers who combined to put on a "really good show".

A Notice and a Plea

Due to a number of factors it has not been possible, since taking on the editorial function last spring, to catch up and produce the intended four issues this year. It seems logical to accept the situation as it is and leave Volume 11 with only three issues. As a partial compensation this issue is larger than usual.

The next issue, therefore, will begin Volume 12. It should be out in March but there will be no point in doing so if there is little to publish. So, mail, fax, or 'phone your contributions, suggestions, or comments. As well as news and views, the *Bulletin* could be an excellent vehicle for overview articles that will tell others what is going on in your particular part of the nuclear endeavour.

The deadline for the March issue will be mid-February.

Note du Président

Hugues W. Bonin

Comme ce numéro du *Bulletin* de la SNC va paraître juste avant les Fêtes, je voudrais profiter de l'occasion pour vous souhaiter mes meilleurs voeux à l'occasion de la Noël et du Nouvel An, ainsi qu'à votre famille.

Les derniers mois ont été fertiles en activités de toutes sortes, surtout sur le plan international. La conférence ENC'90 de Lyon a permis à Messieurs Ken Talbot et Peter Stevens-Guille, ainsi qu'à moi-même, de rencontrer plusieurs représentants des autres Sociétés nucléaires. M. Talbot et Messieurs Stan Hatcher et George Pon ont été très actifs à faire la promotion de la Conférence "Énergie Nucléaire et Environnement" proposée à Toronto en Octobre 1993, et d'après moi, ils ont très bien réussi à susciter l'intérêt et le support de leurs auditeurs.

M. Talbot et moi-même avons rencontré M. Peter Feuz, Secrétaire Général de la Société Nucléaire Européenne et nous avons pu discuter en détail d'un accord éventuel d'échanges entre nos deux Sociétés. Nous nous attendons à recevoir sous peu une ébauche de document d'entente de la part de la SNE. J'ai eu aussi l'occasion de rencontrer le Professeur Andrei Yu. Gagarinski, Secrétaire Exécutif de la Société Nucléaire de l'U.R.S.S., et le Dr. Dai Chaunzeng, de la Société Nucléaire Chinoise. Nous avons résolu d'intensifier les échanges entre les Sociétés.

Un déjeuner offert par la Société Française d'Énergie Nucléaire m'a donné l'occasion d'en apprendre davantage, en causant avec M. Michel Rapin et M. Jackie Weill, Président et Délégué Général de la SFEN, respectivement, sur les programmes d'échanges d'étudiants entre la SFEN et les autres Sociétés Nucléaires. Je compte bien pouvoir mettre sur pied un tel programme d'échanges d'étudiants entre le Canada et la France dans un avenir très rapproché.

Le Dr. Stevens-Guille a eu la sentillesse de me remplacer à une réunion du Conseil International des Sociétés Nucléaires. Malheureusement, il est resté plusieurs questions majeures en suspens, et on espère que la prochaine réunion à Washington en novembre pourra se terminer par une entente et la fondation officielle du Conseil.

Aussitôt après la Conférence de Lyon, je participais au Quatrième Colloque de Science et de Génie Nucléaire de l'Université McMaster et j'ai eu le plaisir d'y rencontrer le Dr. David Beattie, qui servit de liaison entre l'Australian Nuclear Association et la SNC. Il m'a transmis une ébauche de document d'entente entre les deux Sociétés qui sera soumis sous peu au Conseil de la SNC. J'espère bien avoir l'occasion de discuter d'échanges avec les dirigeants de la Société Nucléaire Mexicaine lors de leur Première Conférence Annuelle.

Une autre grande nouvelle est la réunion du Comité Conjoint ANC/SNC de l'Éducation, des Ressources Humaines et des Communications qui s'est tenue à Kingston le 18 octobre dernier. Considérant la température plus que maussade, on serait tenté de surnommer ce comité "le Comité Mouillé".... Les 11 participants étaient d'accord sur l'urgence de produire une brochure sur les carrières dans le nucléaire et ont discuté fébrilement de projets éventuels et de la nécessité de poursuivre le travail des deux ancien comités. On a fixé la date de la prochaine réunion du Comité pour le 4 décembre à Toronto. Si ces questions de main d'oeuvre, d'éducation et de communications vous intéressent, n'hésitez pas à vous joindre à ce Comité.

Le Comité des Prix de la SNC va reprendre ses activités sous peu et va lancer un appel pour la nomination de candidats pour le Prix de l'Excellence. Il y a sûrement plusieurs personnes autour de vous qui méritent ce prix et ce serait dommage qu'elles ne puissent concourir pour ce prix parce que personne n'a pensé à soumettre leur candidature.

Les membres du Conseil et les Officiers continuent de travailler fort dans d'autres domaines tels que le Programme. Vos idées et suggestions sont toujours les bienvenues. Le temps de renouveler votre adhésion approche: c'est le moment idéal d'informer vos collègues sur la SNC afin de leur permettre aux aussi tirer bénéfice des nombreux services que la Société Nucléaire Canadienne vous offre.

Hugues W. Bonin
Président

Message from the President

Since this issue of the CNS *Bulletin* is to be out close to the Holidays, I would like to take this opportunity to wish all CNS members and their families a Merry Christmas and all the best for the New Year.

The recent months have been quite hectic, notably on the international front. The ENC'90 Lyon conference permitted Ken Talbot, Peter Stevens-Guille, and myself, to meet with representatives of other national and international nuclear societies. Mr. Talbot, Dr. Hatcher and Dr. Pon were very active in promoting the 'Global Conference' proposed for 1993 in Toronto, and my impressions are that they did a tremendous job and scored high, in raising interest and support.

Ken Talbot and I met with Peter Feuz, Secretary General of the European Nuclear Society, and discussed the broad lines of an eventual agreement of exchange between the CNS and the ENS. The ENS is expected to send the proposed memorandum of agreement to us shortly. I had the occasion of meeting with Prof. Andrei Yu. Gagarinski, Executive Secretary of the U.S.S.R. Nuclear Society and with Dr. Dai Chaunzeng, of the Chinese Nuclear Society. Further exchanges with these Societies are expected in the near future.

At a luncheon offered by the Société Française d'Énergie Nucléaire, I learned more from the President, Mr. Michel Rapin and the Délégué Général of the SFEN, Mr. Jacky Weill, about the student exchange program that SFEN has with other nuclear societies. I hope it will be possible to implement such a program between the CNS and the SFEN in the near future.

Dr. Stevens-Guille replaced me at the meeting of the International Nuclear Societies Group. Some major points were left for further discussion among the Nuclear Societies and it is hoped that at a meeting in Washington in November, the International Nuclear Societies Council will be formally founded.

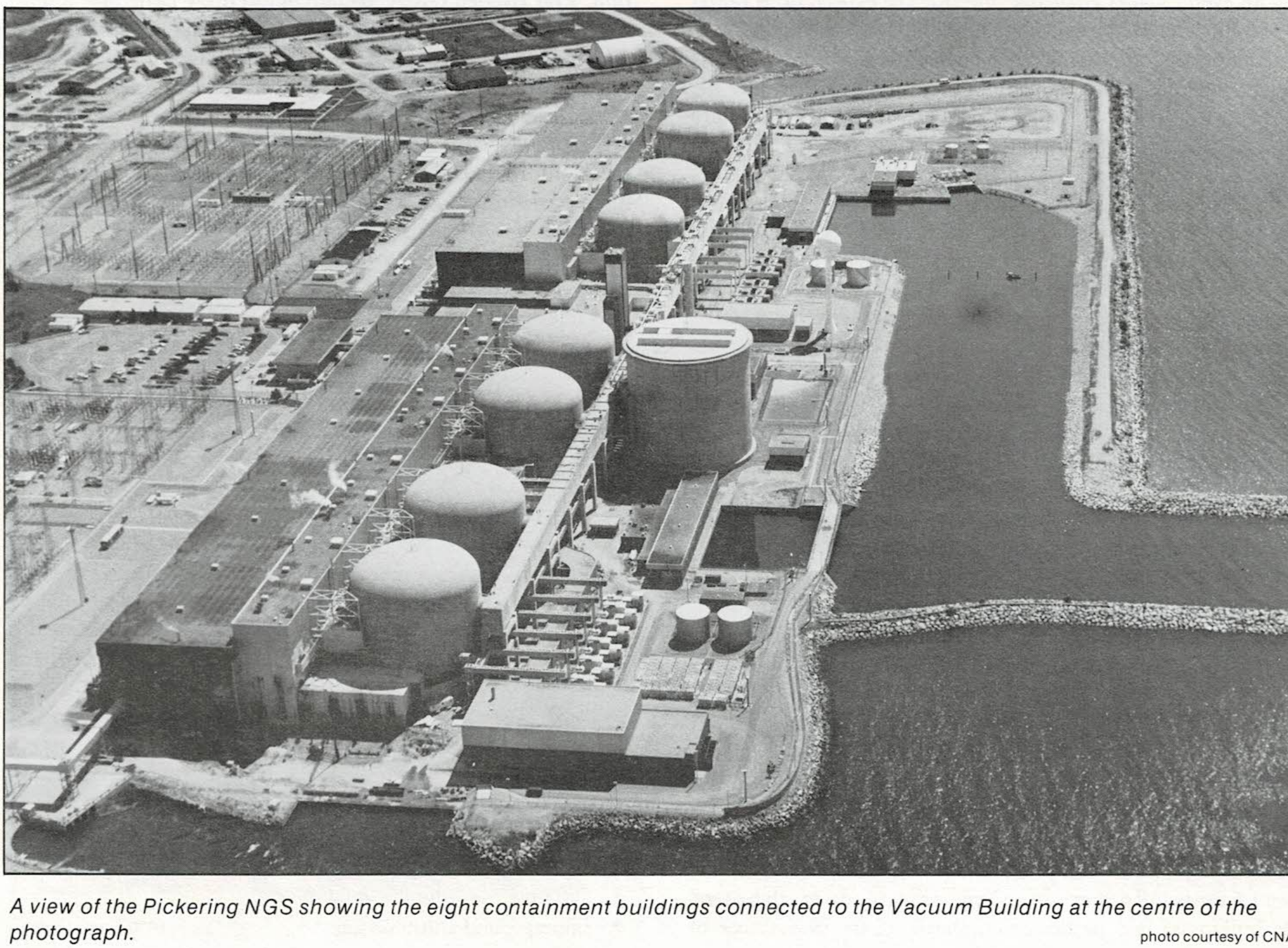
Right after the Lyon Conference, I had the pleasure of meeting Dr. David Beattie at the McMaster University Conference, who served as a liaison between the Australian Nuclear Association and the CNS, and gave me a proposal for an agreement between the two Societies for submission to the CNS Council. It is also my hope that I will be able to contact Mexican Nuclear Society officials at its First Annual Conference and propose a draft for a memo of understanding between the two Societies.

Another great piece of news is that the joint CNA/CNS Education, Human Resources and Communications Committee met October 18 at R.M.C., Kingston. In view of the rainy and windy day, we might as well nickname the Committee the "Wet Committee".... The 11 participants agreed that a brochure on careers in nuclear science and engineering was needed urgently and discussed other possible action items and the necessity to resume the work of the former two committees. Another meeting of the Committee is scheduled for December 4 in Toronto. Anyone interested in these topics is more than welcome to join this Committee.

The CNS Award Committee will resume its activities soon and will issue a call for nominations for the Best Achievement Award in the coming weeks. Surely there are people around you that deserve this Award; it would be a pity that they miss this reward because no one thought of nominating them.

Your Council members are still very active in other areas such as the Program. If you have ideas and suggestions, please do not hesitate to contact us. Membership renewal time is approaching fast. Now is the perfect time to recruit some of your colleagues in the CNS and allow them to enjoy the services we can offer you.

Hugues W. Bonin
President



A view of the Pickering NGS showing the eight containment buildings connected to the Vacuum Building at the centre of the photograph.

photo courtesy of CNA

Second International Conference on Containment Design and Operation

The Second International Conference on Containment Design and Operation was held by the CNS in Toronto, 14-17 October 1990. Paul Burroughs was the Conference Chairman and Duane Pendergast the chairman of the Technical Program Committee.

In the following pages are reports on the conference, beginning with an Overview by David Mosey and several summary notes on various sessions, prepared by the session chairmen. Also included are the opening remarks by Bill Morison and the as-presented version of an IAEA paper which gives an international perspective to the topic.

Overview *by David Mosey*

With more than two hundred delegates attending from eighteen countries and over seventy technical papers, the Second International Containment Conference must rank as another major success for the Canadian Nuclear Society. Not only did the conference come up to the high standards of quality and quantity that the CNS has traditionally maintained, but it also met an even tougher challenge: meeting the expectations raised by the First International Conference, held in Toronto in 1984.

The agenda of a conference such as this is shaped by its plenary sessions which indicate in broad outline the route the conference is to follow, the questions it will address and, more generally, the present context and future direction for the more detailed issues addressed in the technical sessions. In this respect October's conference built solidly upon the foundations laid in 1984. At that conference, which addressed the question of containment design and containment's ability to accommodate severe accidents from a variety of national and regulatory perspectives, there was a remarkable degree of agreement across technical and national boundaries. Though individual technical solutions to containment challenges must clearly be system-specific, the general nature of that challenge, events beyond the design basis were not. There was general agreement that containment designs had very generous safety margins. For example, a US delegate pointed to analyses suggesting ultimate containment strength might be 2 to 4 times design and that steam explosions of sufficient energy to fail containment were simply not realizable. Furthermore, melt-through of the containment base-mat was simply not a significant possibility.

"Containment designs [have] very generous safety margins."

In 1990 there still appear to be good grounds for confidence in the performance of existing containment structures – as Dr Jankowski noted, "there is no reason to believe that a properly designed, constructed and maintained containment will fail before 1.5 times DBA pressure and will probably do much better." Dr Jankowski laid particular emphasis on the importance of maintaining containment integrity throughout the life of the plant, stressing the importance of building inspectability into containment design.

Operability of containment, that is operability in the course of the evolution of an accident was a particularly strong theme in the conference. In a remarkably elegant and erudite presentation, Phil Holden (AEA Technologies) drew particular attention to the possible lessons to be learned from fuel reprocessing facilities where, because of the relatively long time periods for accident development, accident management systems have always been installed. These, he pointed out, are getting simpler and more rugged. Mr Holden placed considerable emphasis on the point, reiterated by other speakers, that accident management provisions must be carefully selected to match the unique demands of a specific reactor system. He reminded the conference that arrangements such as filtered air discharge systems or hydrogen recombiners or igniters should not be regarded as universal panaceas, noting for example, that while filtered air discharge systems afforded opportunities for accident management it also added an additional role for containment by-pass. This reflected ongoing concern in the UK with this particular containment failure mechanism. As Anthony Edwards pointed out in the 1984 conference, beyond DBA studies had predicted three-quarters of all predicted containment failures would be in the form of containment by-pass.

Looking to the future, there seemed to be general agreement that, satisfactory though the current generation of containment designs might be, they are not appropriate for the year 2000, particularly in view of a world-wide political/social climate in which it may become necessary to argue that releases *cannot* take place, rather than that they *will not*. Though our ability to predict failure modes is improving it will never be 100 per cent, therefore it becomes essential to be able to demonstrate that all the inevitable uncertainties have been accommodated. Possible future directions include:

- stronger containments
- "second", or double containments
- underground construction

- evolution of plants which inherently pose less challenge to containment, i.e. small, modular units with passive safety systems.

Of major importance is the need to ensure that accident management systems are backed up by better information to the operator – as Mr Holden suggested, "we have a long way to go" on that particular issue.

"The current generation of containment designs [are] not appropriate for the year 2000."

Another warning note sounded by Mr Holden, and echoed by other speakers and questioners during the discussion periods, was the danger that the "presentational", or perceptual, advantages of any particular approach to containment might override the technical advantages.

The whole question of how much "public acceptance", a rather vague concept, is tending to drive containment design seemed to be a powerful, underlying agenda item throughout the plenary sessions. Indeed, in his introductory remarks, 1984 Conference Chairman Bill Morison addressed the question of public acceptance directly, identifying it as "one of the major challenges" facing the nuclear industry today and posing the question "what can we do specifically with our containment systems to improve public acceptance?" Technical Chairman Duane Pendergast echoed this, suggesting that perhaps "the containment systems of our reactors will become a symbol of nuclear power's minimal environmental impact" and made a direct link between the issues to be raised and discussed at the conference and public acceptance, suggesting that characterization and resolution of containment issues "will help lead the way to understanding of nuclear power and energy supply issues." In the discussion periods the topic resurfaced several times, and it seemed clear that many people felt a major driving force in containment development is "public perception" or "public acceptance." Professor Golay questioned the proposition that public acceptance might be gained by "showing the public better hardware," pointing to public opinion polls which suggested that technology per se was less the issue than confidence in the institutions operating and regulating that technology. And Mr Holden reiterated the important point that while the containment concept is central to the demonstration of high standards of safety for nuclear power plants, it cannot be considered in isolation from related technical issues specific to an individual plant's design. The same approach will not necessarily be the best for all designs, he emphasized, an implicit warning of the dangers of letting "presentational" considerations override technical ones.

One particularly important perspective was missing from this discussion, and that was the regulatory view. A strong feature of the 1984 conference was the degree of participation by representatives of regulatory authorities. Certainly, as any attendee at the earlier conference could attest, presentation and discussion of the regulatory perspective was one of the liveliest and most illuminating aspects of the plenary sessions. It is a little disappointing that no representative of the Canadian, or any other, regulatory body could be persuaded to participate in the plenary sessions at the 1990 Conference.

This aside, the 1990 Conference on Containment Design and Operation must be accounted an outstanding success from both an organizational and a technical viewpoint. Building solidly on the foundations laid by the 1984 conference, it provided a focus for the international understanding of containment issues and, as review of the technical sessions reveals, provided an invaluable forum for the broad spectrum of specialties that are involved in what is perceived to be a fundamental nuclear safety issue.

Session Summaries

Plenary Session A

Performance of Containment Systems for Water-Cooled Nuclear Power Reactors, M.W. Jankowski.

Containment Research Overview, K. Soda.

PWR Accident Mitigation Measures: A French Point of View, J. Duco.

M.W. Jankowski's paper presented a wide-ranging review of the issues underlying containment design and performance. Containments have been designed conservatively in the past and therefore wide margins of safety exist, capable of accommodating not only design basis accidents but also most degraded core accident sequences. Future designs will consider severe accidents and their mitigation using passive countermeasures and accident management. This is possible in part because researchers are elucidating the complex phenomena involved in severe accidents.

After reviewing the potential threats to containment integrity and countermeasures to ensure low leakage of fission products under anticipated accident conditions, Dr. Jankowski turned to operational matters. He drew attention to the procedures needed to permit frequent monitoring of containment isolation and suggested ground rules for future containment design and operation. For example he suggested that future ground rules might include model testing at at least one-tenth scale and appropriate analysis to guarantee structural integrity to three times the design pressure. Other examples were conservative basemat thickness and devices to disperse core debris in a core melt accident.

K. Soda presented an overview of containment research emphasizing the progress made in the past three or four years. He explained that the objectives were to quantify the safety margins and reduce the consequences of accidents. Dealing with mechanical and thermal loadings to the containment, he identified steam explosions, hydrogen combustion, core-concrete interaction, high pressure melt ejection and high temperature melting of polymers used in electrical penetrations through containment, as areas of "beyond design basis" research activities. Some twenty-five references were provided to illustrate the progress that has been made on these issues.

Containment performance has been evaluated experimentally using scale models. A one-eighth scale steel containment model tested at Sandia failed at five times the design pressure. Reinforced concrete containment vessels have been tested in the US ($1/6$ scale) and Japan ($1/4$ scale) and both failed at three times the design pressure. A prestressed concrete (Gentilly-1 type)

CANDU containment at $\frac{1}{14}$ scale was tested at the University of Alberta and began to leak at about 2.7 times the design pressure. The ultimate failure pressure was calculated to be about 4.7 times the design pressure.

Substantial research is being performed into phenomena affecting accident management. Important remedial measures include hydrogen igniters, filtered venting, pool scrubbing, containment sprays and fan coolers. This part of the presentation was of a general nature but some fifteen organizations were identified as being active in research into containment accident management.

J. Duco presented the French philosophy with regard to severe accident mitigation. In the event of a core melt, the containment and the various systems passing through it must constitute the ultimate line of defence. Radioactive releases to the environment must be compatible with the off-site short-term emergency plans for population protection.

If at some time (e.g., 1 day) after the accident it was determined that the source term was a factor of ten higher than could be accommodated by short-term protective measures, then mitigation procedures would be employed. The ultimate procedure, U5, is based on operator-controlled filtered venting of the containment, beginning one day after the onset of the accident at the earliest. Sand bed filters have been developed and qualified at full-scale as effective tools for the removal of aerosols from discharged gases. Other multi-stage containment filtered venting systems have been developed around the world and some are being installed in power plants. M. Duco concluded that the remedial measures he had described should improve public acceptance of modern LWR's which he believes are already safe from a technical standpoint.

In the discussion session Dr. Soda said that he had not meant to exclude the potential detonation of hydrogen-steam-air mixtures and that all possible threats to the containment must receive attention from the researchers. Dr.Jankowski was asked whether containment should be designed to withstand the most severe accidents. He said that in his presentation he had been trying to focus on current "Western Design" PWR's and BWR's where significant margins almost certainly exist but in some cases they remain to be demonstrated conclusively. This demonstration should have a high priority. He emphasized that design pressure depends on containment types and reactor types. In other parts of the world there is a lack of information with which to assess safety margins, and basic experimental data appear to be lacking. He suggested that for new containment it might be appropriate to spend 5 per cent of the capital investment on testing to establish the design margins of the containment.

Dr. Soda said that future research should be concentrated on molten core coolability and also fission product behaviour in containment and the potential of release to the environment.

When asked what test procedures exist in France to ensure that filter valves do not become stuck shut, M. Duco replied that the valves to containment venting systems are of a very uncomplicated design and they are manually operated. Work is being done to ensure adequate shielding of the operator from activity release to the filters.

Dr. Soda was asked whether any tests were being done on back pressures building up behind the liner in a long lasting accident sequence. He knew of none. Dr. Soda was also asked whether the many types of polymer penetrations through containment had been tested in simulated accident conditions. Only one representative polymer was under test.

Asked whether the filter beds on French PWR's would retain molecular iodine effectively, M. Duco replied that the filters were efficient removers of aerosols but not molecular iodine. The molecular iodine has been shown to be trapped by painted surfaces inside the containment.

Dr. Soda was asked what consideration is being given to alleviating inservice degradation of older plants. Dr. Soda said this is an important area for future research. Dr. W. Beckner (US NRC) said that licensing renewal work in the USA would involve evaluation of the containment performance margins over the remaining plant lifetime.

J. Clive Wood

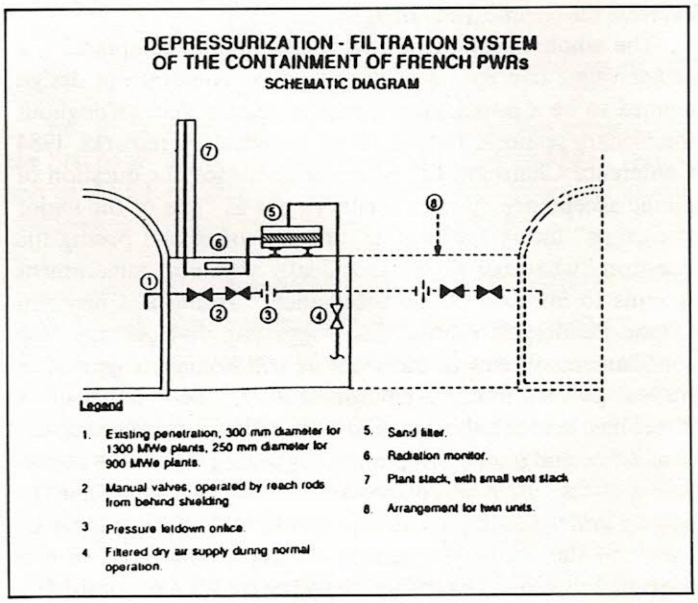


Figure 1 – *Depressurization-Filtration System of the Containment of French PWRs: Schematic Diagram.*

Plenary Session B

The audience received three excellent presentations ranging from new issues to be addressed in future containment designs, novel features of containment design for future plants and finally to the key or fundamental question of whether or not to contain.

The session was led off by Phil Holden, AEA Technologies, UK, with a comprehensive summary of containment issues arising from recent work on beyond design basis events and from PSA studies. Mr. Holden believes that containment by-pass is one of the most difficult issues to deal with. The concept of containment venting, Mr. Holden claims, may be simply trading one problem for another. While it provides some mitigation for severe accidents, it deliberately introduces another potential containment by-pass mechanism. Therefore, the total cost of the plant may be increased significantly with no reduction in the overall risk.

The second paper was presented by Dr. Bernard Kuczera. He dealt with the issue of core melting and novel design features to be considered in future PWR designs to mitigate such accidents. The paper presented results of bounding analyses, and of energy releases from core melt scenarios to determine the ultimate containment structural integrity requirements. On the basis of these calculations, Dr. Kuczera concludes that passive containment cooling schemes are required to reduce the loading on the containment structure. These schemes include a double containment structure (steel inside and concrete outside) with air channels in between to induce air flow by natural circulation.

The third paper was presented by Prof. Golay. He examined the central issue of whether or not to contain. His basic premise is that containment is an insurance policy against failure of other safety systems (shutdown & core cooling). He examined the concepts of confinement and containment, where in his opinion, containment minimizes the risk to the public and confinement only reduces the public risk to levels consistent with capital cost constraints. He defined "containment" as a system which precluded any release to the environment. "Containment" allows for a planned release at some time after an accident. In the end, Prof. Golay believes that the ultimate goal is neither risk limitation nor risk minimization, but public acceptance of nuclear power plants. And, rightly or wrongly designers and proponents of nuclear projects will do what is necessary to gain public acceptance, even if that is the wrong thing to do from an overall risk viewpoint. In his view filtered venting is one such case.

Discussion Period

The interest and audience participation stimulated by the three papers was very high, as can be judged by the large number of questions posed to the panel – more than what could be handled in the one hour discussion period. A small sample of the questions addressed to the panel and their responses follows:

Does the panel believe that the future designs of safety systems should be based on PRA and not on design basis events?

Safety system design (including containment) should be based on a solid, conservatively based safety philosophy. PRA has a place in the design process, in ensuring that all failure modes of concern are indeed considered and addressed in all design. This in effect may help to identify new or additional design basis events.

In Canada, anti-nuclear groups have criticized the single unit containment (Gentilly-2 and Point Lepreau) because it does not have a vacuum building and have criticized multi-unit plants with a vacuum building because they do not have separate containments (Pickering, Bruce, Darlington). How does one deal with such apparent public confusion/misunderstanding?

The key is to not get into a comparison of currently operating reactors with new designs, because this puts the industry in a no win situation. Such comparisons will ultimately be used by anti-nuclear activists to reach the conclusion (unjustifiably) that older reactors are not safe enough.

We seem to evaluate containment and reactor safety on an individual basis. Are there any special requirements arising from considerations such as operation of thousands of reactors on a global scale?

One such requirement would be the global harmonization of reactor safety requirements, but this is not likely to take place in the immediate future.

Assuming the upcoming decision on Sizewell B is to not require filtered venting, how will this be sold to the public, given that other countries are installing filtered venting?

Filtered venting is not a panacea for all potential accident conditions. In fact, it helps in some cases and hurts in others, but worst of all it introduces another containment by-pass possibility.

Why are steam explosions inside containment being considered for future German PWR designs?

PRAs have suggested that this is a problem that needs to be addressed.

What are some examples of dominant containment by-pass scenarios?

Steam generator tube failure is one such scenario.

A. Natalizio

Session 1: Commissioning and Operation

This session was an interesting review of the activities and problems facing any operations group in working with a containment structure. Subjects ranged from commissioning of concrete containments to the ultimate operation of filtered venting following a loss of coolant accident. Three papers dealt with leakage aspects, one with in-service inspection of a prestressed concrete structure and one with work practices required to allow extended maintenance in multiple reactor containments.

S.S. Bajaj of NPC (India) discussed the experience with a double-shell design which evolved from the original reinforced concrete, to a pre-stressed concrete design in later stations. The papers on leakage included Ron Mills' (University of Toronto) most interesting dissertation on the behaviour of concrete, detailed insights on its structure and the causes and dynamics of leakage. Claude Seni (AECL) suggested that it may be possible to extend Mills' work to the point where a localized monitoring system would give sufficient information on concrete condition to reduce the need for full-scale testing, which requires a station outage. Claude Seni's own paper dealt with the enhancement or recovery of leak-tightness of concrete structures using a special polymer coating applied to the inside of a CANDU-6 structure. This prompted a suggestion by P. Chul-Yong (Korea) that testing this coating should be extended to post-LOCA environmental conditions. Still in the area of leakage, H.T. Hill (BCP Technical Services) provided a clear picture of the difficulties in obtaining meaningful leak-rate values in the large microclimate at the containment enclosure.

Session co-chairman, H. Asher (USNRC) reminded us of the importance of maintaining confidence in the integrity of the stressing tendons in concrete structures and outlined the in-service inspection requirements needed to confirm that integrity. The key requirement is to check the tension in the tendons and this is usually accomplished through pulling one head off its seat or de-tensoring, then re-setting. Ron Mills suggested that we should now be able to install simple load cells under each cable head and provide continuous or periodic load-monitoring capability.

In CANDU nuclear stations in Ontario, four reactors occupy a single containment volume, which presents special problems when extended maintenance must be carried out on a single reactor. Bob Barton (Ontario Hydro) covered these in his description of work practice and structure which was applied at the Pickering Generating Station for the large scale fuel channel replacement at Unit 3. One end fitting was assembled to its pressure tube outside the reactor building and the access airlock had to be fully open to accommodate the long component. Since this would normally breach containment, the pressure panel to the vacuum duct was sealed with a testable structure.

Filtered venting systems are being back-fitted to many stations around the world for post accident containment pressure control. The activated charcoal filters for iodine removal in the CANDU Emergency Filtered Air Discharge (EFAD) system was described by Jon Holtorp (Ontario Hydro). Since this filter deteriorates with time, testing is required, and Holtorp presented details of an efficient system for testing using a freon flow pulse. The topic of filtered air discharge is an important one, as was evinced by the attention paid to the subject in the plenary sessions, and it is difficult to over-emphasize the importance of simple design, high availability and ease of operation in such vital elements in the containment system.

V. Austman
H. Ashar

Session 3: Reliability, Risk and Severe Accident Evaluation

About 30 to 50 people attended this interesting session. The thrust of most of the papers presented was to describe the reliability and performance of containment systems and subsystems in a realistic manner.

The first paper, *Evaluation of Mark I Containment Under Severe Accident Pressurization*, presented by J. Marti of Spain, calculated the pressure parts of the containment were the expansion bellows connecting the containment with the pressure-suppression torus. While this location failed at 0.5 MPa, the containment shell would not fail until 1.05 Ma, or 2.5 times the design pressure. The author stressed that the maximum failure pressure depends on the local, specific details of the containment construction.

The second paper, *A Risk-Based Approach to Assessing CANDU Containment Reliability Requirements*, by K. Dinnie of Canada, showed clearly that from a risk point of view, some containment subsystems were much more significant than others. The paper was an excellent example of how probabilistic risk analysis techniques can reveal the distortions created, sometimes, by deterministic design rules. Not only was the overall target of 10^{-3} yrs/yr containment unavailability well below that needed to satisfy risk-based safety goals, but the importance of subsystems to risk varied by orders of magnitude. Somewhat surprisingly at first glance, pressure relief valves and the vacuum building mattered much less than hydrogen ignition systems.

The third paper, *A New Modelling Approach for Containment Event Tree Construction: Accident Progression Stage Event Tree Method*, by N. Watanabe of Japan, addressed the complexity of probabilistic risk assessments: too often they can be understood only by the people who did them, if that. The authors proposed a method for breaking the accident progression into stages, each with common characteristics, and linking the stages by accident-specific interface parameters. The result was fewer event trees but with the failure mechanisms and dependencies preserved. In the question period, people probed the key issue of selection and definition of the interface parameters.

The fourth paper, *Proving Test on the Reliability for Reactor Containment Vessel*, by A. Nonaka, reported on a very comprehensive test programme ongoing in Japan. The test matrix included hydrogen mixing, hydrogen burning, radioactive material trapping and structural mechanical behaviour. The presentation inspired many questions and a lively discussion, during which it became clear that the mixing times of the steam and the helium (used as a hydrogen simulator) in the facility were quite short.

The fifth paper, *Application of Thermal-Lag Analyses to Equipment Qualification for a Main Steam Line Break Environment Inside Containment* by J. Scobel of the U.S.A., presented an approach to equipment qualification by calculating transient temperature profiles in various components. Although the worst-case MSLB temperature exceeded both the worst-case LOCA temperature and the environmental qualification temperature for a short period, the calculations showed that the thermal inertia of the components prevents them from exceeding their EQ limit.

The last paper, *Evaluation and Verification of the Reliability of Pressurized Heavy Water Reactor Containment and Associated Engineered Safety Features*, presented by S. Bajaj of India, dealt with a reliability analysis of an Indian PHWR containment system. The results were used to help determine the in-service surveillance programme and the frequency of spurious containment isolation. Some design changes were made where the reliability analysis revealed a simple improvement. There was a lot of discussion on the basis for the assumptions and component failure data, including the correction of generic data to account for local conditions.

In short, reliability analysis, structural analysis and tests were all used as tools to gain a good understanding of the real behaviour of containment for both design-basis and beyond-design-basis events.

V. Snell
Z. Tichy

Session 6: Activity Transport Experiments

Seven papers were presented in this session. All of the papers dealt with Canadian projects in the area of activity transport as aerosol and of fission product chemistry.

The first paper was an overview of the Canadian containment safety program in the areas of hydrogen mixing and combustion, fission product chemistry and activity transport as aerosol. This paper was intended to set the stage for this session and the Canadian combustion papers presented in Session 12.

The second and the third paper discussed the aerosol program at AECL Research. S.R. Mulpuru detailed the CANDU-specific experiments carried out in the Whiteshell Laboratories and Chalk River Laboratories to characterize the structural material and fission-product aerosol generated from fuel/cladding samples heated to 2000° C. B.H. McDonald described the approach and the codes for modeling aerosol behaviour in CANDU reactors. CATHENA/PACE has been developed for the primary system and CATHENA/PACE – 3D is under development for containment. An Integrated Aerosol Response

Software (INTARES) is also being developed to run other codes in parallel to account for the influence of other phenomena such as chemistry and combustion on aerosol behaviour. The suggested approach is applicable to other reactors and other thermalhydraulic and aerosol codes as well. B.H. McDonald also described initial results from experiments aimed at establishing scaling between fresh water/salt water mixing and light gas/heavy gas mixing for application to hydrogen mixing in containment.

The next two papers dealt with the large-scale Water Aerosol Leakage Experiments (WALE). These were presented by R.J. Fluke and K.R. Weaver. In these experiments, a flashing jet (such as that expected from pipe breaks in the primary cooling system) is discharged into a vessel with vents and a variable-distance impingement plate. A cesium salt tracer helped track the distribution of unflashed water that could potentially contain active material in accidents. Results indicate that impingement is the dominant droplet removal mechanism. The carry-over through the vents, in all cases, was limited to less than one per cent, implying a cloud density in the vessel of less than $10 g/m^3$. The carry-over consisted of a significant fraction of 'fines' (less than 2 μ m in diameter). These appear to be produced by the flashing process.

The last two papers dealt with the results from the Radioiodine Test Facility experiments. R.J. Fluke indicated that some of the significant findings from the experiments and their simulation with the iodine chemistry database, LIRIC, are that (a) gas phase iodine concentrations are low, (b) zinc-primer painted surfaces provide a major sink for iodine, and (c) organic impurities increase iodine volatility only in the presence of radiation. W.H. Kupferschmidt provided the results of an investigation into the reaction mechanism that leads to the adsorption of aqueous iodide onto zinc-primer painted surface observed in these experiments.

K. Tennankore

Session 7: Activity Transport Analysis

This session brushed in broad strokes over fission product behaviour in containment. The six papers provided a good overview of the field, and were well attended, with standing-room only for several presentations. Fission product behaviour is still, clearly, an area where much can be done with a simple model and modest expenditure.

The first paper, *The Liric Database/Model,* presented by G.J. Evans, was appropriately fundamental: it described how the chemical reactions important to iodine behaviour in containment were compiled and checked. Well over 100 reactions are modelled. There was some discussion on the accuracy of organic iodide modelling, as a reaction has to be postulated to account for the observed concentrations.

The next paper, *SMART: A Simple Model for Activity Removal and Transport*, presented by S. Quraishi, described an accident analysis tool which captured the radionuclide behaviour in containment within the confines of a personal computer. It showed that most of the processes of interest in an accident can be modelled fairly simply, and in a conservative direction. The model is in further development.

The refinement of margins in accident analysis was covered in the third paper, *The Development of Radiological Consequence Accident Analyses Methods for the UK PWR*, presented by R. Tout. Using the Sizewell-B reactor, a more realistic release from the building was obtained when more detailed models of fuel behaviour, aerosol behaviour, etc. were used. This is a good example of the theme of the session: much can be gained in this area.

The last three papers dealt with potentially the hardest task of all: accurate prediction of fission product behaviour in large-scale containment tests – namely, the Light Water Aerosol Containment Experiment (LACE) programme. J. Tills presented *CONTAIN Code Calculations for the LA-4 Experiment* which showed both the difficulty of adequately characterizing an experiment beforehand, and good results once the importance of certain experimental features were understood and modelled. In *CONTAIN*, both the thermalhydraulics and the aerosol behaviour are calculated. In the long discussion, the importance of decay heat in affecting the results of a "real" accident was emphasized, as opposed to the experiment.

F. de Rosa presented *Use of IDRA Code for Calculation of Fission Product Transport and Retention in the Containment: Comparison with National and International Experimental Results.* Reasonable agreement was obtained with a simple model of aerosol behaviour. As is the case with *SMART*, the thermalhydraulics must be input.

The University of Pisa and ENEA thermalhydraulic simulation of LACE was presented by S. Paci, in *Thermal-Hydraulic Analysis of the LACE Experiments and Its Fall-Out on the Safety Analysis of the LWRs Containment System.* The issue in discussion was what was the best way to integrate thermalhydraulic and fission product codes; or did they even need to be integrated? Not according to at least two of the authors of the models presented.

This is a productive and changing field, which should have much to say at the next International Containment Conference.

V. Snell
Z. Tichy

Session 9: Containment Design

The authors of the first paper submitted were unfortunately unable to attend the conference to present the paper. It described a Russian district heating reactor design based on passive safety concepts. A secondary vessel with a large water inventory and "sluggish" reactor design ensure long response times. For all (even severe) accidents analyzed, core cooling is ensured.

The second paper described French "expert" computer software being developed to aid post-accident response. It utilizes activity measurements at the stack, in the coolant, secondary side and sumps as well as the containment atmosphere and in auxiliary buildings. Approximately 60 penetrations are covered. An automatic search of possible leak paths and possible corrective actions are presented earlier than otherwise possible. Information is fed back to their centralized Emergency Response Centre.

The third paper, from Sandia, was a thorough analytical study of ice condenser containments for severe accidents using the *CONTAIN* code. The threats imposed by direct core heating and hydrogen combustion were mitigated most effectively by inerting and combining cooling system depressurization with back-up power for the hydrogen ignition system. The large uncertainties due to % corium contribution to direct heating were acknowledged. The H_2 threat was felt to still be significant even if direct core heating were eliminated. Inerting, although effective, introduces operational problems and the risk of occupational casualties.

In the fourth paper, from Westinghouse, the results of heat transfer sensitivity studies were presented for the emergency fan coolers transfer of heat from containment to the cooling water system. Quantification of equipment margins allows for operational flexibility or in compensating for fouling, increased service water temperatures or degraded flowrates. Environmental qualification relief was another benefit mentioned.

The fifth paper gave the outcome of an Ontario Hydro work history and constructability review study. Its objective is to reduce costs and construction schedule in future designs. The objectives can be achieved by designing for constructability, integrating engineering and construction planning, modularizing the plant, and parallel work, for example. Only limited benefit can be gained from modularization if an existing plant design (such as Darlington) is repeated, however. An important point made was that Project experience is *precious and perishable.*

A broadly based paper from India concluded the session with a description of their Standardized PHWR containment design. This includes a double containment with an interspace at negative pressure. This allows relatively higher leakage rates for these epoxy/vinyl covered concrete containments (typically 0.25%/h at design pressure with leakage approximately linear with pressure). The design incorporates a water spray (a water suppression pool in later designs) to reduce overpressure and an internal air clean-up system consisting of charcoal and particulate filters. The role of instrument air inleakage as a source of slow repressurization is now recognized.

Following the session there was considerable interest in an informal video showing Ontario Hydro's "design for constructability approach" as it applies to the reactivity deck at the Darlington generating station.

G.D. Zakaib

Session 11: Containment Response

The six papers in this session were presented to audiences ranging from 20 to 40 people.

The first three papers dealt with validation and comparison of containment computer codes against experimental data and international standard problems. Clearly identified by several speakers was the need to refine such models and support them with good experimental data in the area of long-term phenomena, particularly natural circulation.

The remaining three papers dealt with design calculations and model verification activities related to the Indian 500 MW(e) PHWR containment and stimulated a number of questions principally related to safety margins and conservatisms in the design.

G.M. Frescura

Session 12: Hydrogen Combustion

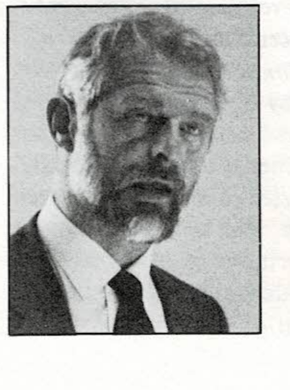
Eight papers were presented in this session. The first four papers were on the consequences of hydrogen combustion as determined in specific experimental assemblies for selected conditions. The next two papers dealt with dispersion/distribution of hydrogen in reactor containments. The last two papers described the development of combustion mitigation devices.

M.N. Carcassi made brief presentations on the first two papers. The first paper was on extracting turbulent burning velocity from the SANDIA experiments in the FLAME facility using a one-dimensional representation of the flame. This showed that the maximum turbulent burning velocity is reached for 13% transverse venting. This disagreed somewhat with the conclusion reached in the fourth paper by C.K. Chan in which an analytical model of flame acceleration by obstacles when applied to small-scale experiments showed that even a small amount of transverse venting dramatically suppresses flame acceleration. The difference is attributable to the different distribution of venting area in the two experiments. In the second paper, M.N. Carcassi, based on his experiment and those of others, demonstrated that the combustion properties of lean and rich mixtures are about the same if interpreted in terms of the limiting reactant. The third paper by R.K. Kumar clearly showed the mitigating effect of steam in precluding obstacle-induced flame acceleration in a 1.5-m diameter cylindrical vessel. Discussion following these papers indicated the need for developing a scaling strategy to apply these results to reactor containments.

Lumped-volume analysis of hydrogen distribution in Indian PHWR (paper by S.S. Bajaj) showed that hydrogen concentration resulting from metal-water reaction never crosses flammability limits in the containment while the mixture becomes flammable for a few minutes in the vault. Accounting for long-term radiolysis indicated the need for hydrogen management by mixing and containment venting. Hydrogen distribution experiments in the decommissioned HDR containment (paper by L. Valencia) demonstrated the tendency for temperature and steam stratification during blow-down from the mid-region in the containment and the tendency for hydrogen to accumulate in the top regions of the containment where the steam concentrations are high. This stratification persists for a long time. One of these experiments is now being offered as an International Standard Problem for an OECD-CSNI code comparison exercise.

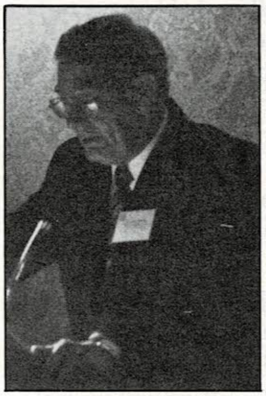
G. Koroll presented a promising concept for passive hydrogen removal using a forced-flow catalytic recombiner. Tests carried out in an 8-cm diameter pipe containing a 20-cm long catalyst bed indicated that greater than 90% removal is obtained for hydrogen concentrations as low as 1%, for a residence time as low as 0.1s. Full-scale and qualification tests are required before the technique can be applied for hydrogen mitigation in containments. K. Blinn presented details regarding the catalytic and spark igniters developed for the deliberate ignition strategy under consideration in Germany. Extensive qualification tests of these igniters indicate that they are suitable for the expected post-accident containment atmospheres.

K. Tennankore



R. Bye of the UK Nuclear Installations Inspectorate gives one of the very few papers from regulatory organizations.

Introductory Remarks *by W.G. Morison*



Bill Morison

Good Morning, and a special welcome to Toronto to those who come from other places. I'd also like to welcome all of you to this conference on Containment Design and Operation. It's a pleasure for me to be here and to give a few opening remarks.

This is an important and timely opportunity for the nuclear power industry to share information and technology to improve the safety and public acceptance of nuclear power. Containment systems capability, which will demonstrably protect the public against harm as a result of any unexpected events in our nuclear facilities, is probably the single most important feature leading to universal acceptance of nuclear power.

About six years ago, in the spring of 1984, I chaired the first International Conference on Containment, here in Toronto, sponsored by the Canadian Nuclear Society. Also in the fall of 1984, I delivered a joint overview paper on Containment Systems Capability, co-authored by containment authorities in the United States, West Germany, Sweden and Canada, to the plenary session of the Fifth International Meeting on Thermal Nuclear Reactor Safety in Karlsruhe, Germany. From these meetings I had a pretty clear picture of the status of containment capability in 1984.

It appeared at that time that the various containment systems being used could effectively cope with the "Design Basis Accidents" as defined by the jurisdictions in which the nuclear power stations were located, and that containment designs had substantial capability to mitigate even more severe accidents. Frankly, at that time containment systems seemed to meet containment requirements and most known problems were either resolved or being resolved.

As I recall, the major containment challenges in Canada with the Pressurized Heavy Water Reactor Program, were:

- the need for in-service leakage testing to periodically confirm containment integrity;
- the assurance of reliability of the containment envelope heightened by failures of the vacuum building roof seal and deterioration of roof seal cables;
- the development of methods to delay or reduce the extent of atmospheric venting of containment because of post accident pressurization due mainly to instrument and process air release inside containment.

In Canada, the future focus was on hydrogen generation and behaviour in containment and on fission product behaviour, and increasing attention was being placed on large stagnation LOCA's combined with assumed containment impairments.

Internationally, in 1984, the Industry Degraded Core Rulemaking program (IDCOR) in the USA was completing the establishment of comprehensive technically sound positions on the issues related to potential severe accidents in PWR and BWR stations. At the time the major issues were:

- degraded core sequences, including steam explosions and hydrogen detonation, leading to containment pressures above the design value
- generation of non-condensible gases including hydrogen
- core retention mechanisms
- containment pressure relief
- post-accident behaviour of fission products inside containment.

Information available in 1984 from the United States, Germany, France and Sweden indicated that containments would be capable of withstanding over-pressures several times their design pressure, and research also indicated that in the unlikely event of a severe accident combined with containment failure, release of activity would be gradual, several days after the severe accident. It was clearly recognized in 1984 that containment was necessary as the ultimate line of defence, preventing the escape of radioactive materials, if combined failures of other equipment, systems and humans occur.

The importance of containment was underscored in 1986 with the accident at Chernobyl. Hindsight tells us that a more complete containment envelope might have greatly alleviated the consequences of that event. Concerns continue to be voiced regarding the adequacy of containment of some early nuclear stations such as the early VVER's and the RBMK's units.

Today the general public continue to view containment as the key ultimate barrier in the defence in depth they expect us to provide to ensure their protection in the event of equipment and human failures. In response, industry has taken action to ensure containment integrity for a range of low probability, severe accidents, which could lead to containment pressurization. Filtered containment venting systems have been added to a number of units in Sweden, France, and Germany, to prevent overpressure in the event of these postulated severe accidents, thus going beyond the containment requirements of 1984. There have also been a number of large scale containment structure overpressurization tests to establish the significant margins between the design pressure and postulated over-pressures which may lead to significant leakage.

"Containment is one of the most easily understood safety concepts [by] the general public..."

Experience during the past 6 years has also reinforced the importance of human behaviour and operator performance on safety. In recognition of the important role the operator plays in ensuring public safety and containment integrity, a session covering containment commissioning and operating experiences has been included in the program at this conference.

This conference covers a wide range of other topics related to containment: – design, regulation, reliability and risk, activity transport and analysis, hydrogen combustion, venting and so on. I believe good progress is being made in improving understanding, design and performance of containment systems to minimize the impact on the public of a wide range of postulated accident situations. I hope and expect this conference will contribute to continuing progress.

In looking more broadly at energy production and utilization which may have an impact on mankind, one of the most important changes in public perceptions since the first containment conference in 1984, has been the increasing recognition that the combustion of fossil fuels may be modifying the world climate through release to the atmosphere of greenhouse gases. Environmental pollution and potential changes to the future climate in the world, and the resulting impact on the future of mankind is one of the most widely discussed topics today.

This insight has raised cautious optimistic expectations that perhaps nuclear power might be turned to as a way to sustain societal energy needs while reducing atmospheric discharges. To earn public support, nuclear power must overcome its negative safety image. Overcoming this negative safety image and gaining public acceptance of nuclear power is one of the major challenges facing us in the nuclear industry today.

There are many actions the nuclear industry can be and are doing to improve our safety image – improved safety culture throughout the nuclear industry, improved safety concept, simpler/safer designs, more care in operation, more attention to risk and safety in the public school curriculum, better more understandable public information, more openness, and so on.

But what can we do specifically with our containment systems to improve public acceptance? I believe "containment" is one of the most easily understood safety concepts that the general public can relate to, whether their concerns are nuclear or toxic chemicals or whatever. They can see and feel massive concrete and steel structures which separate them from the plant inside.

First I believe we must ensure that our existing containment systems are capable of protecting the public from all credible accidents or combinations of accidents that may otherwise release radioactivity to the environment. (What postulated "accident sequences" we have to include, will probably have to be tested with our public in some way which they can relate to – most people have difficulty relating to our familiar risk terminology of ten to the minus "X".) This requires thorough safety and risk analysis supported by safety research and investigation and improved communication.

Secondly we have to test the containment systems periodically to ensure they are in place and will operate effectively when required.

Thirdly we have to ensure the containment systems are operated safely and maintained thoroughly by well trained operators who are striving for continual improvement in safety performance. And we have to let the public see our dedication to safety and our caring and careful attitude.

Fourthly we have to continually advance containment technology to understand weakness in our existing systems and so we can implement improvements where needed in these existing stations and for our future stations.

Some people are coming up with new reactor designs which are intended to reduce the requirements on the containment systems, others are developing novel containment systems with passive containment heat removal systems utilizing natural convection designs. There are many novel ideas. I'm sure you each have ideas where containment system performance may be improved. I favour building on our experience and improving where needs exist.

This conference provides you with an excellent opportunity to put forth your own ideas and to advance your knowledge of containment technology.

Have a good conference.

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:

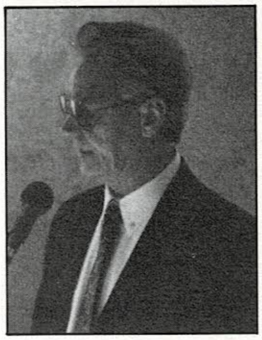
P.D. Thompson
NB Power
Point Lepreau Generating Station
P.O. Box 10
Lepreau, New Brunswick
E0G 2H0

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.

Performance of Containment Systems for Water-Cooled Nuclear Power Stations

M.W. Jankowski, E. Yaremy
International Atomic Energy Agency, Vienna, Austria



Dr. M.W. Jankowski

BACKGROUND

Presently, the only international guidelines or standards on nuclear reactor containment are given in the IAEA's Nuclear Safety Standard (NUSS) documents. These were prepared on the basis of a consensus among all Member States with nuclear power programmes and reflect actual practice, mostly based on the design-basis-accident (DBA) approach. At present, consideration is being given to undertaking revisions of the Codes and Guides to reflect development in the evaluation of beyond-design-basis-accidents ("severe accidents") and their implications for existing design requirements.

Developments in the evaluation of severe accidents and their possible consequences have led to IAEA activities in the evaluation of containment performance for conditions beyond the design basis based on present basic design requirements and practices. The Technical Committee on Severe Accident Containment Design Bases, organized by the IAEA in 1988, covered a wide range of containment related topics concentrating on exploring common approaches to the question of severe accidents in relation to containment design requirements. A summary of the work is given in the following paper.

In the area of containment design, it was apparent that the DBA concept is used by all Member States. Differences in containment design are primarily due to differing national practices and reactor types. There is a widespread belief (supported by a large amount of analytical work) that wide margins of safety exist in containment designs which are capable of accommodating most degraded core accident sequences. Probabilistic safety assessment (PSA) methods have been applied in some countries to check the adequacy of the containment design, and to help in deciding whether to include in design considerations certain external events (such as aircraft impact). The application of PSA, however, is limited by the relatively large uncertainties in the results.

The design of future reactors may include the consideration of severe accidents, stressing the importance of measures to mitigate the consequences of accidents, including passive countermeasures and accident management.

In the area of research and development, efforts in many areas are directly applicable to the evaluation of containment design and the assessment of safety margins. In order to make full use of severe accident research, it is most important to understand the complex phenomena involved and to adopt reasonable methods of containment evaluation. This will provide the basis for containment design. The reliability of the investigations needs to be carefully stressed however. Research and development on the structural integrity of containments is receiving much attention. Part scale and full scale model tests are recommended to resolve the uncertainties in the structural response and ultimate load estimates for the containment.

A report is being prepared by the IAEA dealing with certain aspects of containment loads and the responses to them. The report examines the containment system reserve margins and offers general observations regarding possible considerations for future design upgrading. This paper summarizes the report's findings.

INTRODUCTION

The concept of design basis events (both transients and accidents) has been developed over the years and used to test the adequacy of nuclear power plant design. Design basis events were intended to represent a sound composite engineering judgement regarding the reasonable range of events that might occur, and were thought to define a reasonable envelope of all credible events. Thus, the design of each plant was required to be capable of withstanding the consequences of those events considered credible. Generally, the most severe of this set of design basis events in terms of jeopardizing the containment and its associated systems are the spectrum of loss of coolant accidents (LOCAs). These accidents serve to set the requirements for a number of safety systems, including the emergency core cooling system (ECCS) and the design of the containment building.

The design of containment varies according to the reactor type, the philosophy of the designer, the country, and the date of design of the unit. Containment variations are further differentiated by: the experience of the designer; engineering factors; differences in national regulations; differences in perceptions of the extent to which provision must be made to deal with postulated low probability events; and the manner used to apply these considerations in design. Further differences result from the different policies in various countries concerning retrofits (backfits). For example, differences in containment design arise in the use of vented filtered containments; the use of accident localization systems; the design of suppression pools; and the extent to which accident management considerations are taken into account. Despite these differences, some convergence exists.

DESIGN BASIS ACCIDENT LOADINGS

It has become almost universal practice to require that the reactor system be enclosed in one or multiple containment structures. These have to be low leakage barriers designed to retain the majority of radioactive materials that may be released. The containment is designed to fulfil the requirements arising from the DBA philosophy with the main objectives of:

(a) withstanding the maximum expected fluid dynamic forces during postulated events; and

(b) guaranteeing low leakage under all normal operating and anticipated accident conditions.

The design basis for a large dry containment is normally determined by pressure and temperature buildup due to flow resulting from the break of a primary coolant system pipe. In the event of a double ended rupture the containment will be subjected to a maximum pressure typically ranging from 0.3 to 0.5 MPa overpressure.

Containment design practice also requires not only that the containment shell has to withstand the maximum pressure rise, but also that internal structures must withstand local pressure differences. Dynamic loadings resulting from pressure differences on internal structures and pressure waves were found to be irrelevant, in general, to the DBA concept. Local pressure differences occur in milliseconds rather than seconds and are virtually eliminated within tenths of a second.

Most regulations do not require that all the events leading to dynamic loadings be assumed to occur simultaneously in the initial stage of a LOCA. Because of the highly dynamic character of the typical loadings, however, some regulations (for example, those of the United States NRC) require a careful frequency response analysis of the relevant structures. In addition, some national regulations (e.g. those of the USA and the UK) require that containments be designed to withstand the effects of a major earthquake simultaneously with the effects of the DBA. Most other national regulations consider an earthquake and the DBA as independent loadings. These stipulations require additional containment resistance both within and beyond the design basis loading conditions.

BEYOND DBA LOADINGS

At the present time, beyond-design-basis loadings are not covered by national regulations on containment and containment systems design. There are two reasons for this: containments have built-in safety margins based on conservative design practices; and a considerable degree of uncertainty attaches to the whole process of core degradation, relocation and its influence on containment failure mechanisms.

Regulating beyond DBA loadings, in view of conservative design practices would lead to excessive containment design requirements, necessitating reserve margins in addition to those already included in the design.

"If the challenges to containment grow sufficiently large, failures will occur."

The uncertainty about core degradation makes it impossible to cover the spectrum of postulated beyond-design-basis events and their associated loadings on the containment structure. For core degradation to threaten containment integrity, it must be postulated that an accident sequence progresses to core melt. Such events, which are beyond the design basis, are still under extensive study in many countries. The consequences of core degradation and core melt progression on containment integrity (including the various loading mechanisms) are also very design specific. In most cases, the loading phenomena are overestimated as a result of the use of conservative, rather than best estimate, applications of existing knowledge (to compensate for uncertainties about the phenomena).

CONTAINMENT SYSTEMS RESPONSE

Containment pressure boundaries can withstand challenges beyond those considered at the time of design. This is due in part to the conservative assumptions typically made in estimating the forces and temperatures associated with design basis accidents and in part to the conservatisms inherent in design practice. However, if the challenges to the containment system grow sufficiently large, failures will occur. Further, there always exists the possibility for containment bypass because of equipment malfunction, faulty maintenance, or human error.

Pressurized water reactors (PWRs) operate at high pressures and there has been a trend to use large dry containments relying on a relatively high design pressure and a large containment volume. Failure of these containments are possible in the absence of containment heat removal (as shown by station blackout sequences). Early failure may be postulated if direct containment heating occurs but there are numerous uncertainties.

There are also designs that utilize a passive ice-based system to condense steam during an accident. These designs are susceptible to hydrogen combustion and igniters have been installed to control hydrogen combustion. However, accident sequences involving station blackout would comprise the igniters and make the containments potentially vulnerable to failure from hydrogen explosion in events that release significant hydrogen. Otherwise, the possibility of early containment failure depends, as in dry PWR containments, on the pressure of the primary coolant system and the availability of heat removal system.

Boiling water reactors (BWRs) operate at about one half the pressure of PWRs and have smaller containments with pressure suppression systems to ensure containment function during accidents. Most BWRs have automatic depressurization systems which can lower the primary system pressure and reduce the likelihood of a high pressure core meltdown. Mark I and Mark II containments are inerted and, thus, not susceptible to early hydrogen combustion within the containment. Leakage in the space between the containment and reactor building can, however, lead to hydrogen combustion. Mark III containments, like the Mark I and Mark II designs, rely on a water pool to condense steam during an accident but having larger volume containments their atmosphere is not inerted. Igniters are used to prevent the buildup of large hydrogen concentrations. Station blackout accidents, in which controlled burning would not be possible, could lead to early containment failure. Also, failure of the Mark III containment has been postulated to result from containment heating effects if the reactor vessel failure occurred at high primary system pressure.

Finally, all containments can suffer late failure unless long-term pressure and temperature buildup from decay heat and core-concrete interaction can be reversed. Failure could occur in either the containment structure or its penetrations or by basement penetration by core debris. The likelihood of these failure modes depends on individual plant design details and the availability of decay heat removal systems. In some large dry containments, it is possible that the pressure could rise high enough to fail the containment.

Containment leakage design requirements vary quite significantly. Depending on the country and on the particular design, the allowable variations in containment leakage rate are in the range between 0.1 to 10 per cent of volume per day. In practice, however, for some containment types the measured leakage rate is even higher. Increased leakage that would occur from the containment under the pressures and temperatures resulting from beyond-design-basis events is a real feature that is under active study in many countries.

Loss of containment isolation or containment bypass during a severe accident can have consequences as severe as those of a major structural failure. Historical evidence indicates that isolation failures have occurred under normal operating conditions. However, the most recent data indicates that, after operating procedures have been tightened, these incidents are relatively infrequent and, in general, the leaks are small (less than 10 x design). These failures can be associated with either pre-existing openings in the pressure boundary or from the failure of valves used to isolate the major process lines and other penetrations.

"The key question is whether containments [can] prevent the release of fission products in the event of a severe accident."

Pre-existing openings can only be detected with existing procedures in inerted BWR containments. For other containments types, monitoring systems would have to be devised.

In all cases, procedures would have to be developed to permit frequent, if not continuous, monitoring in order to detect the development of an opening. Similarly in cases where isolation failure might develop during an accident, operating procedures have to be relied upon to alert the operator to the existence of the isolation failure and to increase chances of restoring containment isolation.

Since containment relies to a large extent on primary circuit integrity, heavy emphasis is placed on regular in-service inspection, maintenance and repair programmes, together with operational monitoring and alarm systems. Operational procedures and in-service inspection programmes are designed to detect degradation in safety related systems. Integrated leak rate tests are performed on a regular schedule to verify that allowable leak rates of the containment system are within acceptable limits. cal tests of penetrations and valves are scheduled more frequently.

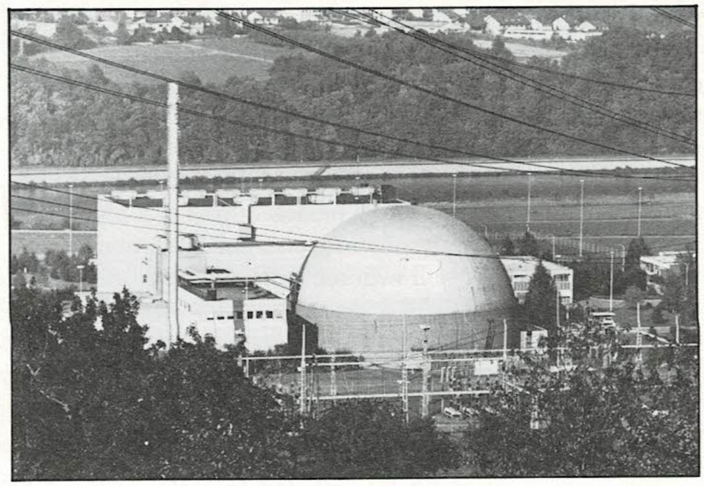
In addition, the in-service inspection programme requires regular periodic examination and testing of the primary circuit structure. Similarly, inspection practices are either in place or under development to assure the continued integrity of steel containments and the steel liners of pre-stressed and reinforced concrete containments. These inspections are generally performed as part of the integrated leak rate tests.

CONTAINMENT SYSTEM RESERVE MARGINS

Studies have indicated that the ability of containment structures to survive challenges could be as high as two or three times the design levels. Because of these margins, present containments are capable of coping, to varying degrees, with many of the challenges presented by severe accidents. For every type of containment, however, there remain mechanisms that could lead to containment failure. The key question is whether containments have the capability of preventing the release of large quantities of fission products in the event of a severe accident.

The provisions of national design codes for containments (e.g. of France, Germany, the United Kingdom and the USA) include margins to take account of uncertainties about actual loading conditions, the variability in material properties and minor inaccuracies in fabrication and construction of the containment.

Consequently, such containments can be expected to withstand loads more severe than those assumed in their design basis. For example, the ASME Code requires that a containment be designed to respond elastically to a pressure 1.5 times the DBA pressure. The code in the United Kingdom requires for the ultimate load condition that the containment remains structurally intact up to at least twice the DBA pressure.



Obrigheim Nuclear Power has a spherical steel containment.

Additional margins are provided by the practice of using minimum guaranteed, rather than actual, material properties for design. Furthermore, code requirements define minimum values whereas actual designs use materials of available sizes and thicknesses that exceed the minimum requirements.

In effect, there is no reason to believe that a properly designed, constructed and maintained containment would fail at less than one and a half times its design pressure and a number of reasons to expect that its actual failure pressure would far exceed this value.

In fact, many containments have been subjected to structural integrity tests, in which responses are measured and compared against design calculations, at pressure levels up to, and in some cases somewhat beyond, full design pressure. All containments are also tested periodically to provide assurance on leakage levels at design pressure. These testing requirements give a high degree of assurance of containment performance if subjected to design basis accident conditions.

Experimental and analytical work performed mainly in the United States and Germany, has indicated that state-of-the-art analytical methods can reasonably predict the failure mode for a steel containment under pressure loadings. The failure will come from either leakage due to deformations at the openings of large operable penetrations or from a gross rupture of the steel shell. Criteria have been developed, based on penetration properties, for deciding if a slow leakage failure is likely. Studies in Germany concerning overpressurization of large containments suggest that a leakage failure at the equipment hatch is a likely failure mode for some plants, but for others a rapid failure of the shell is likely.

In France, large analytical studies have been performed for both 900 MW and 1300 MW types of PWR using finite element idealizations of containments or parts of containment. Depending on the computer codes used, results were rather scattered as far as the pressure corresponding to complete through-the-wall cracking is concerned. Globally, this pressure was found to be twice the design pressure for typical sections in the cylindrical part of containment and dome.

On the other hand, predicted values of ultimate pressure corresponding to complete failure of the containment, due to prestressing tendon rupture were very close and were approximately 2.7/3.0 times design basis accident pressure for both types of units. These values have been checked by means of experimental tests on 1/10 scale models of part of a 1300 MW PWR containment which showed pressure-deformation behaviour that agreed very well with the theoretical predictions. In the UK similar results (2.4 x design pressure) have been obtained in a recent scale model test of a prestressed containment.

Other experimental studies have been performed in France to estimate the difference in the permeability of concrete when the fluid is either air (as in the preoperational test), or an air/water vapour mixture (as in a LOCA). Experiments performed on containment cracked and uncracked concrete samples have shown that the permeability of concrete is 2.5 to 10 times smaller when considering a representative mixture of air and water vapour rather than air alone. This fact obviously increases the actual safety margin of unlined containment with respect to gas tightness.

The state of development of analytical methods to predict nonlinear behaviour is not as advanced for concrete structures as it is for steel. There is less confidence in the capability of analytical methods to predict large deformations of concrete containments. Loads are resisted by concrete, reinforcement and/or prestressing tendons, and the liner. There is not yet a consensus on how to model the transfer of load as the concrete cracks under tension and the reinforcement yields. Some techniques that have potential applicability for concrete pressure vessels (PCPV). Experimental work in the US tends to support the hypothesis that failure in lined reinforced concrete containments will be due to local liner tearing at areas of discontinuity. Additional work will be necessary to verify the dependence of failure mode on the details of liner connection to the concrete shell for both reinforced and prestressed containments. Tests in Canada have indicated that the development of leakage through unlined CANDU containments can be predicted with good confidence.

Another consideration important to the design of the containment is the capability of maintaining complete or partial integrity during core-concrete interactions in the reactor cavity or basemat. Mitigation measures are being considered for some existing containment designs.

In summary, containment design based on loads predicted for the DBA is satisfactory. Containment pressure boundaries can withstand challenges beyond those considered for the design. This is in part due to the conservative assumptions made in estimating the loads and in part to the conservatisms inherent in design practice.

OBSERVATIONS ON CONTAINMENT DESIGN

The key aspects that should be considered in the design of plants to provide optimum capacity to survive challenges to the containment are summarized as follows:

(1) Plants should be designed to exhibit very low leakage under a DBA that is consistent with the operating characteristics of the nuclear steam supply system. Design rules should be specified to give a high degree of confidence that the containment system will perform as anticipated for the operating life of the plant. If these conditions are satisfied, the result will be significant margins that can accommodate loadings beyond the design basis.

(2) Consideration should be given in design to ensuring and demonstrating that if the containment is subjected to loads beyond its design basis the failure mode of the containment will be the one with the least adverse consequences. This will require that design rules be adjusted to ensure that less desirable failure modes are precluded. Assessments of failure modes can be performed using static analysis for most loading conditions. Suitable account should be taken of uncertainties in loadings estimated from severe accidents scenarios.

(3) Since it is important to ensure containment integrity for the operating life of the plant, consideration must be given at the design stage to the inspectability of the containment pressure boundary. Provision should be made for any necessary maintenance, repair or replacement of items that are essential to the continued integrity of the containment pressure retaining boundary. It would be necessary to consider utilization of on-line leakage monitoring. Tests performed during plant shutdowns provide a limited degree of confidence in ensuring continued integrity.

(4) For new, especially standardized, containment designs, it should be demonstrated, both analytically and by model tests (at least one tenth scale), that structural collapse will not occur at a pressure below an acceptable limit (for example, 3 times the design pressure).

(5) The design of the containment system should provide a conservative thickness of concrete below the core in order to restrict melted core to within the concrete cavity or basemat and to prevent the diffusion of melted core through the basemat. The use of high temperature resistant materials and special high temperature concrete and the incorporation of features to spread core debris geometrically over a larger area may be anticipated.

To all CNS members and all our readers ... our wish for Peace and Success in 1991

Four CNS Branches make presentations to FEARO's "scoping" hearings

Most CNS members are well aware of the large AECL program, centred at the Whiteshell Laboratories, to develop and prove out the concept for permanently storing high level radioactive waste in deep geologic formations. This concept is now being evaluated by the Federal Environmental Review and Assessment Office. During October and November a panel appointed by FEARO has been holding "scoping" meetings as the second stage in their process. Four CNS branches made presentations to meetings in their area: New Brunswick, Ottawa, Central Lake Ontario, and Toronto.

Following are excerpts from FEARO publications on this issue and copies of three of the CNS branch submissions. The one by Dan Meraw for the Central Lake Ontario branch was given only in oral form. It focussed on the desirability of using "risk" as a basis for evaluation. Finally there is the major part of the presentation by the AECB, giving some insight into the position of that organization.

FEARO Process (from FEARO publications)

The federal environmental assessment of AECL's proposed nuclear fuel waste disposal concept moves into its second stage this autumn with community meetings called "scoping" or issues identification sessions. These sessions follow a round of open houses held by FEARO to explain the review process and to provide the public with an opportunity to discuss AECL's technology for permanently storing high level radioactive wastes in deep, stable, geologic formations. The scoping sessions are to help identify the important environmental and socio-economic issues that need to be considered, as well as alternative waste management options. They are held at an early stage of the Panel's review so that significant issues are not overlooked. These sessions also assist in determining issues AECL must cover in its Environmental Impact Statement. The scoping sessions are relatively informal. The Panel does not look for consensus among participants. Either oral or written comments are accepted.

FEARO Panel

Chairman

Blair Seaborn: retired, former Deputy Minister of Environment Canada, past chairman of the Canadian section of the International Joint Commission;

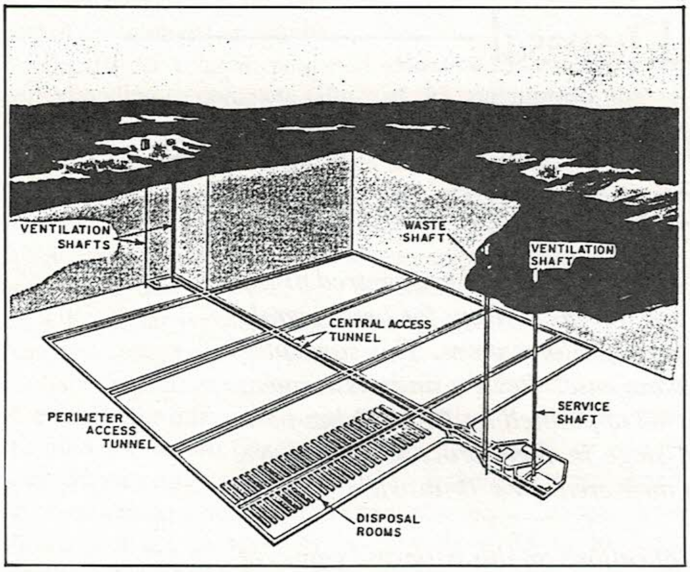
Members

William Fyfe: Dean of Science, University of Western Ontario
Louis LaPierre: Professor of Biology, University of Moncton
Lionel Reese: Chief, Department of Nuclear Medicine, St. Joseph's Hospital, London, Ontario
Louise Roy: environmental consultant
Lois Wilson: President, World Council of Churches
Pieter van Vliet: immediate Past-President, Engineering Institute of Canada

Scientific Review Group (appointed by Panel "to facilitate the evaluation of scientific and technical matters")

Chairman

Raymond Price: Professor of Geology, Queen's University, Kingston, Ontario
James Archibald: Associate Professor of Mining Engineering, Queen's University
Roy Cullimore: Professor of Microbiology, University of Regina
David Duquette: Professor of Materials Engineering, Rensselaer Polytechnic Institute, Troy, N.Y., U.S.A.
Emil Frind: Professor of Hydrogeology, University of Waterloo
Ernest Kanasewich: McCalla Professor of Physics, University of Alberta, Edmonton
Robert Kerrich: Professor of Geochemistry, University of Saskatchewan, Saskatoon
Niels Lind: Professor of Civil Engineering, University of Waterloo
Kwan Yee Lo: Professor of Civil Engineering, University of Western Ontario
Fred Roots: Science Advisor Emeritus, Environment Canada
Rangaswamy Seshadri: Dean of Engineering, University of Regina
Stella Swanson: Consultant, Aquatic Biology, Beak Consultants Limited
Normand Therien: Professor of Chemical Engineering, Université de Sherbrooke
Donald Wiles: Professor of Radiochemistry, Carleton University, Ottawa



The Canadian concept for permanent nuclear fuel waste disposal is to bury the suitably packaged waste 500 to 1000 metres deep in stable rock in the Canadian Shield. A network of underground tunnels and disposal rooms about 2 kilometres square will hold 190,000 tonnes of used fuel.

Branch Submissions

New Brunswick

Mr Chairman, distinguished Members of the Panel, ladies and gentlemen:

I had considered begging leave to commence by showing a few of AECL's slides to illustrate their concept of deep disposal of spent fuel, as well as transportation flask testing, primarily for the benefit of those in the hall this afternoon who may not have had as ready access to this material as those of us within the nuclear industry, since our presentation is the first to be made in New Brunswick. However, they might have been considered as somewhat promoting the concept, and the industry in general, so it is probably wiser not to show them. I fully appreciate that you, the Panel, will already be fully familiar with the concept, and I will therefore be brief.

I hope that I may be permitted to make a few comments at the outset, though, reflecting our views, before specifically addressing the question of the scope of the assessment.

I would like to stress that, in our view, the proposed scheme for underground disposal provides complete protection for mankind and the environment, since in 500 years the activity of a spent fuel bundle discharged from a reactor today will not be appreciably more than that of the original uranium ore. The concept under review is designed to prevent absolutely any leakage of radioactive material from within the storage containers for at least 500 years. Lest this seem a long time, it is short in comparison with the ages of many well-known, manmade structures: Westminster Abbey, the Parthenon, and the Pyramids, to name only three.

I would like to emphasize the need to consider convenient retrieval in your deliberations, since reprocessing may become necessary in the future, as availability of new uranium dwindles, and its price increases. We will look pretty silly in the eyes of the rest of this energy-hungry world to be literally sitting on a colossal source of energy, and be unable to utilize its "unburned" plutonium and uranium. Irretrievable disposal is a luxury we cannot afford.

We think that it is important to bear in mind the care with which radioactive wastes are already handled today, in comparison with non radioactive hazardous substances, which are widely dispersed, do not decay, and hence are forever harmful. In contrast, nuclear fuel wastes are completely contained, closely monitored by both federal and international agencies, and isolated from the environment already.

We would like to state that, in our view, the transportation of nuclear fuel waste is safe, and remind the public that it is already going on. It is a great deal less hazardous than the transport of many dangerous commodities now routinely shipped with hardly a thought, until an accident occurs, that is.

Specifically addressing the scope of the Environmental Assessment, we submit that it should carefully and thoughtfully inquire into the concept of disposal of spent fuel, including transportation of the fuel to the disposal site, to satisfy the informed, reasonable layman, beyond all reasonable doubt, that this concept, including transportation, is viable, and "safe". It is further submitted that the public must be appraised of the work already done at Whiteshell and the Underground Research Laboratory, in layman's language, so that it can appreciate that its concerns have been given very thorough attention, and completely addressed.

We submit that it should NOT deal with whether or not nuclear power generation is necessary or "safe". That is outside the scope of this review, and will be properly dealt with in another forum.

Finally, if this assessment process is to serve the best interests of the country, irrational fears must be somewhat discounted, particularly those so stridently enunciated by special interest groups dedicated to shutting down nuclear power generation, and only arguments based on the physical or social sciences be given serious consideration.

Thank you, Mr Chairman, for allowing me the opportunity to appear before your Panel, to present our views.

Roger Steed

Ottawa

Introduction

It is a pleasure to be able to address this panel as it begins its challenging task.

As you have already received submissions from our colleagues in the Society at your hearings in Toronto, Oshawa and Saint John, our presentation will be brief and will attempt to focus on the identification of issues to be covered in the Environmental Impact Statement and its review, which was the stated objective of these "scoping" meetings.

The members of the Ottawa Branch of the Canadian Nuclear Society (as for the Society as a whole) are individual professionals mostly from the natural sciences and engineering although some are in other disciplines. We are, admittedly, not a group representative of the general population but we do have some relevant experience and knowledge which we hope may be of some assistance to you.

Comments on Terms of Reference

Before offering our suggestions of issues to be considered we wish to note a number of points from the published Terms of Reference for your panel since we feel they are very relevant to the topic of these meetings.

– You are expected to judge whether the concept proposed by Atomic Energy of Canada Limited for the geological disposal of nuclear fuel waste is "safe" and "acceptable".

From our backgrounds in safety analysis and evaluation we believe that evaluation of "safety" can be done objectively. However, the question of "acceptability" poses, we submit, many difficulties. Acceptable to whom? If to the total public, how will its acceptance (or not) be determined? Will the "public" (or the subset of the public that must decide whether or not the concept is "acceptable") be properly and objectively informed of all of the key factors in determining the "safety" of the concept? In this regard we endorse the concerns expressed by our Toronto colleagues about the importance of the public information process.

– You are to "take into consideration" various methods of long-term **management** (presumably as distinct from **disposal**).

We are pleased to see this in your mandate as we, like our colleagues in New Brunswick, urge you to consider the question of retrievability. The spent fuel from Canadian nuclear power reactors contains much potential energy in the unused uranium and plutonium. It is quite plausible that in the coming decades the need for energy could justify retrieving, reprocessing and re-using this great reserve of potential energy.

– You are to include in your review an "examination of the criteria by which the safety and acceptability ... should be evaluated".

Presumably this implies the "development" of such criteria.

This, in our view, is your most important and fundamental task.

In the area of "safety" we recommend a "risk" approach which takes into account the likelihood as well as the severity of any negative effect. (We note the comments on this topic from the Central Lake Ontario Branch of our Society to your Oshawa meeting.) There has been much work on this approach over the past few years. It has been widely adopted in the nuclear field, is extensively used in aviation and communications and is gradually being pursued in many other technical areas where there is a potential hazard. We would be pleased to submit a list of references if the Panel would be interested.

Since "acceptability" is a subjective judgement on a personal or societal level and is outside our fields of experience we will refrain from any specific comment. We do believe, however, that it will be impossible to satisfy everyone. Assuming only a minority object to the concept under study the Panel will have to judge whether or not the objections of that minority are sufficiently cogent to justify turning down a viable approach.

– While you are directed to become aware of [similar] programs in other countries it does not appear that you are explicitly instructed to look at alternatives. Yet it is stated that your review will be conducted under the requirements of the Environmental Assessment Review Program which does include consideration of alternatives.

We suggest that it would be prudent, and render your verdict more credible, if you did examine alternatives to the proposed deep geological disposal. Perhaps this could be accomplished by reviewing the reports and decisions which led to AECL's program and the concept under review.

– The Terms of Reference state that energy policies, the role of nuclear energy, fuel reprocessing policy, and military applications are outside of your mandate.

We are pleased to see this explicit limitation and urge that you enforce it. Otherwise your meetings and hearings will be dragged into the quicksand of a debate that has been conducted in many other fora. As a practical point, nuclear power reactors exist and the spent fuel from them must be dealt with.

Issues

Following that relatively long prologue we wish to offer some suggestions for issues that should be addressed in the EIS and your review.

The first set is drawn from the comments above on your Terms of Reference:

– What are appropriate criteria for evaluating "safety" and "acceptability" of the concept?

– What alternatives are there to the proposed concept of deep geological disposal?

On a somewhat philosophical level:

– Is it necessary, appropriate or logical to attempt to evaluate movements of radioactive material over tens of thousands of years (given the relative brevity of recorded history and the impossibility of predicting the nature of society even a few centuries into the future)?

"What are appropriate criteria for evaluating 'safety' and 'acceptability'?"

Regarding the program:

– Have all the factors that could lead to the release or escape of radioactive material from the proposed vault and all of the possible routes been identified?

– Has the research into these factors and routes and all of their associated parameters been thorough, competent and complete?

– Have all aspects of the transportation of spent fuel from the nuclear power plants, e.g., the nature of the containers to be used, the methods of handling, the form of transport, the likely routes, the probability and consequence of accidents, etc., been thoroughly evaluated?

Thank you for the opportunity to present these thoughts.

Terry Jamieson
Fred Boyd

Toronto

1.0 Background

We would, at the outset, like to make it clear that this presentation is our own personal submission, which we have prepared as interested individuals and as members of the Canadian Nuclear Society (CNS). It should in no way be construed as an official submission from either of our employers.

The CNS is a technical society, established in 1979, whose main objective is to promote the exchange of knowledge in nuclear science, engineering and technology. Its membership, consisting of approximately 650 members, encompasses all aspects of nuclear energy, uranium, fission and other nuclear technologies including occupational and environmental protection, medical diagnosis and treatment, radioisotopes and food preservation. As CNS members, our goal in presenting this submission is to assist in the identification of the technical issues which should be addressed in the Environmental Impact Statement (EIS) and, perhaps more importantly, to stress that guidelines be developed for a comprehensive information program to educate the public on EIS related issues and implications.

2.0 Introduction

The design and construction of a facility to permanently dispose of used nuclear fuel is an undertaking which requires the utmost regard for the safety of this and future generations. The design life of such a facility is measured in terms of millenia, a timeframe that requires the prediction of material properties and behaviours far beyond normal experience. This uncertainty, however, must be balanced against the safety risks of alternate methods of managing a growing inventory of used nuclear fuel. As well, the subject of nuclear waste disposal has become a cornerstone issue with respect to the public perception of nuclear power, an issue that must be publicly addressed with an agreed upon technical and political solution.

The remainder of this submission includes issues which we feel should be included in the EIS Preparation Guidelines.

3.0 Issues Relevant to the EIS

Scheduling: The Panel should review the current schedule for EIS preparation and assess, in its view, whether this schedule is realistic. If necessary, updated scheduling guidelines should be prepared.

Public Information: The success in achieving public concurrence with the EIS results is entirely dependent upon the manner in which the final and interim findings are released, and the extent to which the general public, particularly those communities most likely to be associated with the facility, is involved. In failing to maintain an effective means of communication with the public, or by succumbing to political pressures to stress or to ignore certain facts, the environmental review process may simply become a process mired in bureaucracy and devoid of public faith. Scientists and engineers are beginning to realize that resolution of the nuclear waste disposal issue will be accomplished by public opinion and not by an accepted value for groundwater flow in granite.

With respect to the public information issue, the Panel must assess the following questions:

– What are the most effective methods of educating the public on EIS related issues, and informing them of progress? How successful has the environmental review process been to date in encouraging public involvement? How can this be improved?

– To what extent will the public be involved/consulted prior to the formal public hearings held later in the review? Presumably, a focused educational effort must be initiated in parallel to the preparation of the EIS.

Technical and Related Issues

From a technical standpoint, the central issue is the interaction between the disposal vault (including all engineered barriers) and the environment. This interaction must of course be the major focus of the EIS. There are, however, many other related issues which should be considered as well. These issues may be categorized as follows:

(i) justification of the disposal vault concept
(ii) issues which precede the construction of the disposal vault
(iii) issues which pertain to geographical areas not adjacent to the vault
(iv) issues which pertain to the active operation of the vault
(v) issues which pertain to the period of time following the closing of the vault.

We shall deal with each of these issues in turn.

(i) Justification of the Disposal Vault Concept

The selection of the deep burial method of permanent disposal must be justified from the environmental standpoint. It must be shown that the environmental impact of the proposed approach is less than that of other options. By opting for an irretrievable disposal option, some feel that too much faith will be placed in the hydrogeological assumptions which govern the facility performance. These concerns, valid or not, must be addressed with respect to the associated environmental and moral tradeoffs. The public will want to know why this particular approach has been selected in favour of above-ground monitored storage of the waste.

As well, it is important to compare the AECL concept with similar activities elsewhere in the world. In countries such as Sweden, plans to permanently dispose of used nuclear fuel, and other high-level waste, are in the advanced planning and development stages. Procedures proposed for our disposal facility should be demonstrated to be consistent with the world community's view of acceptable practice in this regard.

(ii) Issues Preceding the Construction of the Disposal Vault

Issues in this category are mostly of a socio-economic nature and would affect the community at the site of the disposal vault, whether this community would already be in existence, or would be established for the purpose of servicing the facility.

– How is the selection of the location of the disposal vault to be determined? Will there be a social component in addition to the scientific/technical component in the siting process?

– What will be the process of communication with the public, especially the population in the area of the proposed vault? How will the wishes and concensus of the local population be ascertained and taken into account in the decision-making process?

– What are the plans for public information and public relations on a continuing basis?

(iii) Issues Pertaining to Other Geographical Areas

When the disposal vault is operated, the used nuclear fuel must be transported to the vicinity of the vault. This creates several issues which must be addressed:

– What will be the method(s) used to transport the used nuclear fuel? What containers will be used, and how will the adequacy of these containers be demonstrated?

– How will the collaboration of the communities adjacent to the transportation routes be secured?

– How will the security of the shipment be assured?

– At the point of shipment of the fuel, what procedures will be in place to ensure the safety of the workers handling the fuel?

– What will be the safety procedures for transportation of the used fuel? What provisions will be made for accident scenarios (i.e., training of emergency response personnel, special equipment, etc.)? What will be the environmental impact of a transportation accident?

In summary, a comprehensive risk assessment of the handling and transportation of the used nuclear fuel should be carried out.

(iv) Issues Pertaining to the Phases of Construction and Active Operation of the Disposal Vault

The phases of construction and operation of the disposal vault introduce several issues which must be studied. They are of both a socio-economic and an environmental nature.

– What are the anticipated economic effects (benefits and drawbacks) of the proposed vault on a nearby community? How many temporary and permanent jobs would be created, and what is the breakdown in terms of job categorization? For what period of time would these temporary jobs be available? Would a community be offered any special incentives for being selected? What indirect effects might be associated with this selection?

– What procedures will ensure an adequate level of safety during the "mining" activities required to construct the disposal facility?

– If the used fuel is to be transferred from a transportation container, to a separate container for permanent storage, how will this be achieved? What are the risks (i.e., possible accident scenarios) associated with this transfer?

– What are the environmental hazards arising from normal handling and packaging procedures associated with storage canister emplacement in the disposal vault? What are the possible accident scenarios that could conceivably occur?

(v) Issues Subsequent to Vault Closure

The period of time after the vault has been filled and closed will be a major focus of attention in the EIS. The Panel should be interested in seeing a number of issues addressed:

– It is important to present the scientific studies relating to the anticipated interaction between the disposal vault and the environment in an abbreviated, but factual and unambiguous fashion. Both experimental evidence and results of predictive techniques (calculations/simulations) should be covered. The predictive techniques should be based on the most advanced models and data.

– In particular, the anticipated rate of release of radioactivity to the biosphere should be addressed. The assessment should cover a "sufficiently long" period of time (i.e., thousands of years). How will the radiation dose traceable to the disposal site compare with the natural background dose?

– What will be the rate of leaching of radioactivity into ground water, and from there into the water table, as a function of time? Will the quality of the drinking water be affected – to what degree and in what timeframe?

– What are the monitoring requirements for the disposal site? For how long will such activity be required and who will bear the costs? What procedures can be used to ensure monitoring continuity? How do we assure that future generations are equipped with the required knowledge about the location of the disposal site and of its character? What would be the consequences of a future generation "disturbing" the disposal site as a result of its existence being forgotten?

4.0 Summary

We have attempted to list, in some detail, the issues which, as interested individuals, we believe should be addressed in the Panel's guidelines for EIS preparation.

In conclusion, we believe that the permanent disposal of used nuclear fuel is necessary, and that to do so now is indicative of our responsibility to manage the wastes we have generated in deriving the benefits of nuclear power. The issue of nuclear waste disposal exists independently of concerns arising from other aspects of the nuclear fuel cycle, such as nuclear plant operation or nuclear plant safety. It is not within the scope of this Environmental Impact Statement to address these other issues (which have already been studied by many inquiries). On the other hand, the Panel may wish to address the comparative transportation and disposal risks associated with nuclear fuel waste relative to those of other energy/industrial sectors.

We believe as well that the Environmental Review process, regardless of the technical conclusions, will be a pointless exercise if public communication and education on this issue is ignored or ineffectively carried out. The ability to convince the public that the disposal concept is sound, and that permanent disposal of used nuclear fuel should be implemented, is of paramount importance.

We have appreciated the opportunity to address the Nuclear Fuel Waste Management Environmental Assessment Panel on this matter.

Ben Rouben
Shayne Smith

The AECB View

Following is part of the presentation by the Atomic Energy Control Board to the FEARO scoping hearings on the nuclear fuel waste management concept.

In the view of the AECB there are three basic issues relating to the management of nuclear fuel wastes which the Panel should address. These issues relate to:

– the strategy for managing nuclear wastes;
– the standards to be used in the review of the Environmental Impact Statement (EIS); and,
– whether long-term safety can be satisfactorily predicted with the necessary degree of confidence.

With respect to the first issue, **the strategy for managing nuclear fuel wastes,** the AECB considers that there are three basic options. These are:

– disposal as soon as possible;
– storage indefinitely; and,
– disposal demonstration.

The first option, **disposal as soon as possible,** involves temporary storage to allow the fuel to cool and to await the availability of a suitable repository, which is likely to take a minimum of 25 years. In this option, disposal of irradiated fuel wastes would occur as soon as a repository was available, without intentional deferral. This option represents permanent disposal with no intent to recover the wastes. Passive containment and isolation would be employed to eliminate any *requirement* for long-term care and maintenance, except for that implied in the temporary storage and placement phases. This period could possibly extend up to 75-100 years from today, which, in this context, is a relatively short time. We expect, however, that any facility, even one *designed* for the so-called walk-away solution, would be monitored indefinitely to verify that it performs as designed.

The second option, **storage indefinitely**, is long-term storage which should be seen as an alternative to prompt disposal rather than being complementary. This option is open ended in that there is no commitment to disposal at a given time in the future. Periods of several hundreds of years of storage are contemplated by advocates of this option.

There is not sufficient knowledge to say how long fuel bundles, as such, could be safely stored. There is not even a common understanding of what *safely stored* means for the long term. However, fuel bundles could be placed in corrosion resistant containers, or in a specially designed above-ground facility when the bundles deteriorate to a certain point. The bundles could be transferred to other containers or another facility when the original ones deteriorated. In principle this process could be repeated indefinitely.

This option would involve perpetual care and maintenance. With this approach, work on the development of the disposal of fuel wastes would not need to be extended beyond concept assessment. Attention would shift to the technology of long-term storage.

The third option, **disposal demonstration,** is intermediate between the above two options. A disposal facility incorporating the essential features of a full-scale facility would be developed and constructed but most of the fuel could be stored above ground, or even in the underground facility in a readily retrievable form as long as desired. Since public acceptance, particularly acceptance by the public in the vicinity of the site of a facility, is one of the major hurdles that would be encountered for any disposal facility, and since such a demonstration might cost a large fraction of the cost of a full-scale facility, a supplementary requirement with this approach would be that the demonstration facility would have to be capable of being expanded to a full-scale disposal facility.

The cost of a demonstration facility may be such a large fraction of that for a full-scale facility that, economically, a proponent might see no difference between the two. Conceptually, however, there is a difference. For example, only a few of the many caverns of a full-scale facility would have to be closed and back-filled in a demonstration facility. The remaining caverns could be excavated and filled with fuel, but not back-filled, in order to make the fuel more retrievable; and the fuel in those caverns could be stored in a more retrievable form than for disposal.

"We expect that any facility would be monitored indefinitely."

In comparing the options retrievability is an issue for two reasons:

- retrievability would facilitate the taking of remedial action if the facility does not contain the wastes adequately;
- in the case of irradiated nuclear fuel, retrievability would facilitate recovery of the fuel for reprocessing, if such a decision is made after the fuel has been put into the facility.

There is therefore more justification for retaining irradiated nuclear fuel in a retrievable form than there is for wastes from reprocessed nuclear fuel. In reality the wastes in a facility would always be retrievable at a price. The nature of the issue is more financial, rather than technical.

The advantages of the first option, that is, disposing of the fuel wastes as soon as possible are:

- the beneficiaries of nuclear power accept responsibility for the waste produced and thus no problems are transferred to future generations;
- passive measures are used to ensure safety and environmental protection;
- it is a permanent solution and can be accomplished within a specified period (50-100 years). This means that costs and performance can be more accurately determined, thus ensuring safety standards are met;
- it would ensure consistency of licensing approach across all nuclear facilities which produce wastes. This is important to ensure that the true costs, social as well as economic costs, of the nuclear fuel cycle are defined;
- it would provide confidence that disposal could actually be accomplished both from a technical and socio-economic perspective;
- although international measures for safeguarding fuel in a closed disposal facility have not yet been established, it is probable that IAEA safeguards for a closed disposal facility would be less extensive and be more effective than if the fuel is stored above ground or left indefinitely in an unsealed underground facility, where it is more accessible for diversion to non-peaceful purposes.

The disadvantages of this approach are that:

- there is some scientific, and considerable public doubt as to whether today's knowledge is sufficient to ensure safety and environmental protection for the necessary length of time;
- there may not be any benefit from any improvements in knowledge that may evolve with time;
- the cost to retrieve nuclear fuel would be relatively high if a decision was later made to reprocess it.

With respect to the second option the advantages of storing irradiated nuclear fuel for an indefinite period are that:

- it leaves more choice for future generations to select energy options because spent fuel would be available in a readily retrievable form for reprocessing;
- a large expenditure of capital for a disposal facility can be deferred indefinitely;
- it allows maximum flexibility for both the operator and decision-makers by delaying decisions until more information becomes available in the future, and to take account of new circumstances;
- it allows time for technology to improve and, possibly, for a reduction in the controversy and social uncertainty regarding the disposal option.

The disadvantages are that:

- it leaves open the question as to how and whether the safety of future generations will be adequately protected;
- it is an open ended process which could allow waste to be forgotten and cause serious safety and environmental impacts in the future;
- active monitoring, security and maintenance would be

needed which are inherently less reliable than passive measures in the long term;

- there is technical uncertainty with respect to how long the fuel would remain stable and relatively easy to handle and store;
- surface storage facilities are more subject to intrusion and other natural and man-made disruptive effects than underground facilities;
- it transfers responsibility for final disposal to future generations and raises the issue as to whether this is morally acceptable;
- it would perpetuate public doubt that high level wastes can actually be disposed of safely and could intensify opposition to the nuclear power option;
- nuclear material in storage would be more accessible for diversion to non-peaceful purposes and would probably require more extensive IAEA safeguards inspections than in a closed disposal facility.

The advantages of developing a demonstration facility are that:

- it would have many of the advantages of the disposal option, particularly with respect to establishing confidence that a proven disposal option is available;
- it results in a lower investment cost than the disposal option;
- it leaves more choice for future generations to select energy options because most fuel could still be available in readily retrievable form for reprocessing, for at least as long as nuclear fuel can be safely stored;
- it could provide a lead period of decades or a few centuries to monitor the performance of the high-level waste facility before the bult of the fuel wastes are actually committed to disposal; any advances in knowledge during that period could be factored into the final design;
- if most of the fuel were stored in an underground facility, even in a readily retrievable form, there would probably be substantial protection in the event that all knowledge of the facility were lost.

The disadvantages are:

- there is still a substantial investment cost;
- there is still a risk that social upset may result in loss of knowledge of the waste fuel when there less than the desirable degree of protection;
- more fuel would be more accessible for diversion to non-peaceful purposes than in the disposal option;

The second issue that we have identified is the question of what standards will be used by the Panel to assess the concept for disposal of spent nuclear fuel.

Any review of AECL's concept should be done against some standard. If the panel intends to use its own judgement it should state the standard on which its judgement is based.

AECB Regulatory Documents contain principles and criteria for the disposal of long-lived radioactive wastes, including nuclear fuel wastes. The relevant Regulatory Documents are R-71, R-72, R-90 and R-104,, copies of which have been supplied to the Panel. The first part of the current version of R-71 is out of date and should be disregarded. This document is in the process of being revised.

Any disposal facility will eventually have to meet AECB standards respecting health, safety, security, international safeguards and protection of the environment. Therefore the Panel is invited to use AECB Regulatory Documents as a basis for its review. The AECB would welcome suggestions on ways to improve or augment these documents and on ways to facilitate their use.

The third issue is whether assurance of long term safety can be achieved prior to operating a repository.

No spent nuclear fuel repository has yet been built or operated anywhere in the world. Thus there is not yet a practical demonstration of the long- or the short-term performance of such a repository to reference. Also the very long time frame needed to ensure safety (thousands of years) precludes any meaningful long-term feedback from repositories by direct observation. This means that confidence in repository performance must be obtained using other means such as predictive modelling and comparison with natural geological systems. Details of the AECB perspective of this issue are contained in the Regulatory Policy documents referred to earlier. However a few key concepts are highlighted in the following recommendation.

The Panel should require that the EIS meets all parts of the regulatory requirements and in addition should check whether:

- the EIS is focused on the critical factors affecting health, safety and environmental protection;
- the EIS embodies a variety of techniques and uses varying levels of detail to predict repository performance;
- the EIS demonstrates that information needed for future siting and licensing decisions is either available or can be practically obtained;
- The EIS demonstrates that the concept assessment has been done in a manner which is usable for future decision-making;
- the conclusions of the EIS are supported by other national or international studies and opinion.

Obviously a successful concept assessment would go a long way to assuring that future generations will not be saddled with an unmanageable problem with nuclear fuel wastes, but does it go far enough? From more than thirty years of regulatory experience the AECB is aware of several developments, some related and some unrelated to waste disposal, which looked good on the basis of paper analyses, small-scale experiments or short-term experience but which did not live up to expectations. Failures are sometimes due to factors which are overlooked in development and are revealed only through actual experience.

It is appropriate to consider the conclusions of previous public reviews as well as international opinion. On the question of responsibility to future generations and the desirability of immediate disposal versus deferral and long-term storage, the following comments are of interest.

The Hare Commission stated in 1977 that:

"surface disposal is unsuitable because it leaves to future generations of man the duty to keep watch on the dangerous substances that we have left behind. Furthermore, surface disposal, even if it is well managed, will always be more vulnerable to man-made hazards such as wars, revolutions and the breakdown of organized society, than disposal deep underground."

The Porter Commission in 1980 expressed the same idea in the following way:

"It would be unacceptable to continue to generate these wastes (spent fuel) in the absence of clear progress to minimize or eliminate their impact on future generations through the avail-

ability of a technically credible and socially acceptable nuclear waste disposal facility."

Recently (1989) the International Atomic Energy Agency (IAEA) published Safety Series #99, "Safety Principles and Technical Criteria for the Underground Disposal of High Level Radioactive Wastes". These principles have since been accepted and approved by the IAEA Board of Governors and thus have general application as part of the basic safety standards of the Agency. In this document the first principle states that:

"The burden on future generations shall be minimized by safely disposing of high level radioactive wastes at an appropriate time, technical, social and economic factors being taken into account"

It also states:

"Principle #11 concerning the minimization of burdens on future generations also implies that these generations should not have to take any action to protect themselves from the effects of waste disposal".

In Regulatory Document 104, *Regulatory Objectives, Requirements and Guide-lines For The Disposal of Radioactive Wastes – Long-Term Aspects*, the AECB adopted a similar principle which states that:

"The burden on future generations shall be minimized by:

(a) selecting disposal options for radioactive wastes which to the extent reasonably achievable do not rely on long-term institutional controls as a necessary safety feature;

(b) implementing these disposal options at an appropriate time, technical, social and economic factors being taken into account; and

(c) ensuring that there are no predicted future risks to human health and the environment that would not be currently accepted."

Passive measures are preferred since history has shown that institutional controls and other active measures are not reliable in the long term. Intrusion has occurred into wastes and land records have been lost on older sites.

R-104 was designed to cover all waste types including uranium mine tailings and is thus worded more generally than if only nuclear fuel wastes had been considered.

The AECB's regulatory approach puts the responsibility for safe management of wastes on the parties that create the wastes, that is, the licensees. This could be accomplished by the AECB making a regulation requiring licensees who produce the wastes, mainly the utilities, to develop a program to implement any necessary future actions.

Viewpoint

Observations

Ed. Note: *The following observations were made by Lt.(N) Doug McDonald, of the Division of Nuclear Safety of DND, after attending two sessions of the "scoping" meetings held by the Panel on Nuclear Fuel Waste Disposal Concept appointed by the Federal Environmental Assessment and Review Office. His comments are, we believe, very pertinent, and we thank him for his permission to reprint them here.*

A report on the FEARO meetings is presented elsewhere in this issue.

The panel members [of the FEARO Panel on Nuclear Fuel Waste] who essentially represent the uncommitted public, face a very difficult task in making a meaningful decision on this "nuclear" issue. The panel is confronted with two polarized and very dedicated groups who are separated from each other by a substantial communications gap. Both groups feel that the opposing side is threatening their very existence. The Anti-Nukes feel that they are being quietly poisoned by hideous contaminants, while the Pro-Nukes feel that irrational fears are tearing down their industry brick by brick.

The failure of these groups to communicate with each other only exacerbates the problem. This failure stems from a refusal to speak to one another in a common language. Pro-Nukes tend to speak in dispassionate risk-based technical jargon, whereas Anti-Nukes speak in emotional consequence-based apocalyptic terms.

With the strengthening of the environmental assessment process, the whole question of nuclear power is rapidly approaching a stalemate unless one side breaks from this standoff and changes its style of communications. Since a stalemate is as good as a victory to the Anti-Nuke side, by default the Pro-Nuke side must make the change and begin to address the concerns of the Anti-Nukes in a direct and non-technical manner, no matter how irrational those concerns may appear. If the Pro-Nukes do not alter their approach soon, the panel and the public will more likely be swung by emotional pleas to save our children than by impassive listings of meaningless risk probability figures.

Dose Limits to be Lowered

Radiation dose limits for workers are likely to be reduced by almost a factor of three, from 50 mSv/y to 20 mSv/y.

Murray Duncan, Manager of the Radiation Protection Branch of the Atomic Energy Control Board, confirmed, in an interview with the CNS *Bulletin*, that the AECB staff would be proposing changes to the Atomic Energy Control Regulations to lower dose limits in response to recent recommendations from the International Commission on Radiological Protection. The changes will be prepared soon after the ICRP formally publishes its recommendations in early 1991. (They were released in draft form in October). The Board has agreed in principle with the staff proposal since its policy has been to base Canadian dose limits on ICRP recommendations.

In its recent preliminary report the ICRP proposes that the occupational dose limit should be 20 mSv/y, averaged over five years, with an over-riding limit of 50 mSv/y in any single year.

For women occupationally exposed the ICRP recommends a special limit if they become pregnant. Once the pregnancy is known the ICRP's position is that the conceptus should not be exposed to more than 5 mSv during the remainder of the pregnancy with a further limitation of 1 mSv during weeks 8 to 15, considered the most sensitive period.

For members of the general public the ICRP repeated its earlier recommended limit of 1 mSv/y. The Canadian limit is still 5 mSv/y.

The proposed changes will particularly affect two groups of radiation workers, uranium miners and pregnant women.

Under the present regulations uranium miners' exposure to gamma radiation and radon daughters are treated separately. Amendments to the regulations approved but not yet issued will require the two exposures to be combined. With the new ICRP recommended limits that formula would remain but the limit will be reduced; that for the gamma component from 50 to 20 mSv/y and for radon from 4.7 WLM/y to probably 2; and a new limit will be imposed for radioactive dust. The overall effect will be a substantial reduction in the effective limit for uranium miners.

The new limits for the foetus, i.e. 5 mSv "for the remainder of the pregnancy", further restricted to 1 mSv during the weeks 8-15, will make it difficult for pregnant women to remain in radiation work in many cases, for example in nuclear medicine.

Assuming that the regulatory limit for members of the public is reduced to 1 mSv/y from the current 5 mSv/y there could be many more people identified as Atomic Radiation Workers. The regulations define an ARW as anyone likely to receive more than 5 mSv/y from occupational exposures. There are a significant number of people working with or around radiation sources who now receive less than 5 mSv/y but more than 1 mSv/y.

Largely due to conscientious application of the ALARA (as low as reasonably achievable) principle the actual doses being received by radiation workers in Canada is well below the current limit of 50 mSv/y. Other than uranium miners the largest category of workers receiving more than 20 mSv/y is that of industrial radiographers.

The ICRP is an international body of experts which has been making recommendations on radiation protection since 1928. Most national authorities follow these recommendations.

Over the last several years, improvement in the estimation of doses received from the atomic bombs in Japan has led to a significant reduction in the estimated doses received by bomb survivors. This factor, together with a longer period of epidemiological follow-up and more complex computer modelling techniques has led to increased risk factors being developed. In its most recent draft recommendations, ICRP uses this new information as the basis for new dose limits.

In fatal risk terms, continued occupational exposure at 20 mSv/y from ages 18 to 64 could lead to an average annual probability of cancer death of 1 in 1300, slightly less than the 1 in 1000 considered tolerable. Put another way, after a full working life, receiving 20 mSv every year, an individual's lifetime risk of fatal cancer could go from about 25 to 29 per cent.

The primary elements of the ICRP's recommendations are referred to as the system of radiological protection: justification of the practice (the practice must produce a net positive benefit); optimization of protection (ALARA, including social and economic judgements); and individual dose limits (which override ALARA for all deliberate exposures). The ICRP has applied its system to three situations: planned (normal operations); potential (accidents or abnormal occurrences), and pre-existing (e.g. contaminated land clean-up). In providing its draft recommendations, the ICRP placed most of its emphasis on normal operations, treating potential situations in a general manner and leaving the application to pre-existing conditions to be handled thoroughly by another working group which will produce a separate report later.

BASIS OF DOSE LIMITS

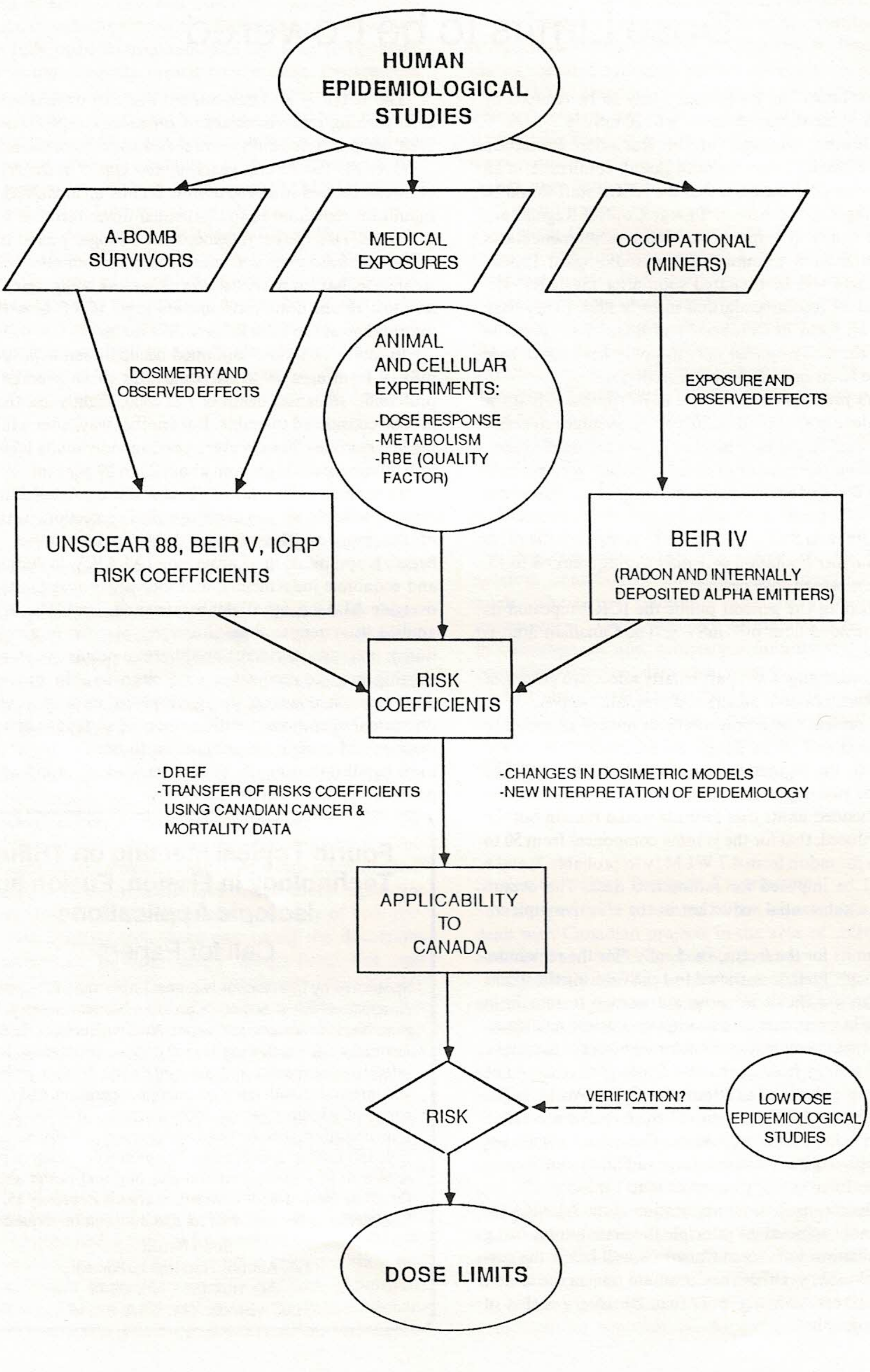


Table1.

BREAKDOWN OF WHOLE BODY DOSE EQUIVALENTS (mSv) BY TYPE OF OCCUPATION (1989)

OCCUPATION	— NUMBER OF WORKERS WITHIN INTERVALS OF DOSE EQUIVALENTS —						TOTAL NO. OF WORKERS	AVERAGE	AVERAGE OF DOSE EQUIV. ≥0.2 mSv
	<0.2 mSv	0.2-0.5 mSv	0.5-5 mSv	5-30 mSv	30-50 mSv	≥50 mSv			
ADMINISTRATIVE:									
ADMINISTRATOR	29	2	3	0	0	0	34	.21	1.40
OFFICE STAFF	2568	134	62	2	0	0	2766	.05	.64
SAFETY OFFICER	13	3	0	0	0	0	16	.05	.27
MEDICAL:									
CHIROPRACTOR	685	55	12	1	0	0	753	.05	.60
DENTAL HYGIENIST	5203	101	59	0	0	0	5363	.02	.63
DENTIST	4879	134	62	2	0	0	5077	.02	.57
GYNAECOLOGIST	26	2	1	0	0	0	29	.04	.40
ISOTOPE TECH (NUCLEAR MEDICINE)	321	100	581	140	0	0	1142	2.11	2.94
LAB. TECHNICIAN (MEDICAL)	2393	264	146	11	0	0	2814	.13	.85
MEDICAL PHYSICIST	155	27	16	2	0	0	200	.20	.91
NURSE	3251	407	190	4	0	0	3852	.08	.53
PHYSICIAN	1289	261	216	17	0	0	1783	.27	.98
RADIOLOGICAL TECH (DIAGNOSTIC)	7552	1468	599	19	0	0	9638	.13	.59
RADIOLOGICAL TECH (THERAPEUTIC)	255	123	226	8	0	0	612	.74	1.27
RADIOLOGIST (DIAGNOSTIC)	1140	266	185	11	0	0	1602	.23	.80
RADIOLOGIST (THERAPEUTIC)	78	25	26	1	0	0	130	.39	.97
VETERINARIAN	1364	149	92	1	0	0	1606	.09	.60
WARD AID/ORDERLY	1310	138	74	3	0	0	1525	.10	.68
INDUSTRY:									
FUEL PROCESSOR	7	4	25	20	0	0	56	4.03	4.61
INDUSTRIAL RADIOGRAPHER	663	143	356	339	42	8	1551	4.81	8.39
INSTRUCTOR (NON-MEDICAL)	92	18	16	1	0	0	127	.25	.90
INSTRUMENT TECHNICIAN	803	129	94	10	0	0	1036	.23	1.02
LABORATORY TECHNICAN (INDUSTRIAL)	2842	362	205	18	0	0	3427	.16	.91
SCIENTIST ENGINEER (FIELD)	367	90	111	16	0	0	584	.53	1.42
SCIENTIST/ENGINEER (LABORATORY)	2483	296	153	11	0	0	2943	.14	.87
WELL LOGGER	345	162	484	59	0	0	1050	1.30	1.94
POWER STATIONS (tritium exposures included):									
ADMINISTRATION	1913	79	69	16	0	0	2077	.13	1.61
CHEM. & RADIATION CONTROL	110	16	99	20	0	0	245	1.30	2.35
CONTROL TECHNICIANS	80	14	32	2	0	0	128	.65	1.73
ELECTRICAL MAINTENANCE	408	87	270	68	0	0	833	1.24	2.40
FUEL HANDLING	8	1	11	17	0	0	37	4.86	6.20
GENERAL MAINTENANCE	1645	182	319	77	0	0	2223	.59	2.24
HEALTH PHYSICS	68	5	14	6	0	0	93	.70	2.58
MECHANCIAL MANTENANCE	386	56	359	245	0	2	1048	3.07	4.85
OPERATIONS	605	147	463	212	0	0	1427	2.01	3.47
CONSTRUCTION	2135	157	317	113	0	0	2722	.62	2.84
SCIENTIFIC/PROFESSIONAL	598	56	120	48	1	0	823	.84	3.07
TRAINING	50	2	12	1	0	0	65	.38	1.61
VISITOR	16	14	22	1	0	0	53	1.15	1.64
MINING:									
URANIUM MINERS	1045	530	2563	374	0	0	4512	1.82	2.37
MISCELLANEOUS:	38217	3911	3219	619	48	10	46024	.33	1.92

Reactor Accidents

David Mosey, Nuclear Engineering International Special Publications in conjunction with Butterworth Scientific Ltd. (1990).

Reviewed by Fred Boyd

This small (108 pp.) book provides concise reviews of seven major reactor accidents and offers insightful discussion on their underlying causes.

Mosey's central theme is that all of these events displayed, to various degrees, evidence of "institutional failure", which he defines as "the impairment or absence of a corporate function which is necessary for the safety of an installation". He shows that this corporate inadequacy was most evident in the Chernobyl accident of 1986, as even many USSR officials now acknowledge.

Institutional failure was also, Mosey argues, the main factor in the TMI-2 incident of 1978 and the SL-1 fatal accident in 1961. The other accidents examined, NRX (1952), Windscale (1957), Fermi-1 (1966), and Lucens (1969), all demonstrated this problem although the author notes the early state of the technology at the time of the NRX accident and the pressure imposed by the military program on the Windscale operation.

In his concluding chapter the author provides an interesting discussion on institutional failure, pointing out the following significant factors:

- a dominating production imperative
  - this refers to the pressure to keep operating or to get the job done quickly, as exemplified by Windscale and Chernobyl;
- a failure to allocate adequate or appropriate resources
  - this refers to both equipment and people;
- a failure to acknowledge or recognize an unsatisfactory or deteriorating safety situation
  - Windscale, SL-1 and Three Mile Island are cited as prime examples;
- lack of appreciation of the technical safety envelope
  - this, according to Mosey, underlies the above three points;
- failure to define and/or assign safety responsibility clearly
  - this, Mosey contends, is a key factor and quotes Rickover (of US nuclear navy fame) who accepted ultimate responsibility for any accident, even on a ship at sea for a long time.

Mosey concludes with a short discourse on "safety culture", arguing that the concept is too vague and can only be a starting point. It is necessary, he states, to develop "clear definitions of the safety elements of all corporate functions on an institution-specific basis."

The author refers to some relevant work by the Advisory Committee on Nuclear Safety of the Atomic Energy Control Board as one indication of the growing interest in the subject of his book. Reportedly the International Nuclear Safety Advisory Group of the International Atomic Energy Agency will be publishing a report on this topic early next year.

Anyone concerned about nuclear safety (and that should include everyone in the nuclear field) should find this little book both informative and thought-provoking. We can all draw lessons from Mosey's reviews and comments.

What is really necessary is to get senior executives of the nuclear industry, those responsible for "institutional" matters, to read the book and reflect on its message.

Other Books of Note

Fission Product Processes in Reactor Accidents.

J.T. Rogers, Ed., Hemisphere Publishing Corporation. 1990.

This large volume contains the 62 papers presented at a seminar held in Dubrovnik, Yugoslavia in May 1989. Terry Rogers, the editor (and also chairman of the conference) is a professor at Carleton University and an active member of the CNS.

Reflecting the focus of the seminar most of the papers deal with specific aspects of the problem of fission product behaviour in accident situations, grouped in the following categories:

- fuel behaviour and fission product release;
- transport phenomena in the coolant system;
- transport into containment;
- containment transport phenomena.

In addition several papers provide further analyses of the Three Mile Island and Chernobyl accidents.

For those wishing a quick appreciation of the whole topic the first paper, by H.J. Teague of the UKAEA and D.F. Torgeson of AECL-WNRE, provides an excellent overview of the phenomena involved in severe reactor accidents.

Energy Alternatives: Benefits and Risks.

H.D. Sharma, Ed., University of Waterloo Press, 1990.

This is also a compilation of papers from a conference, in this case the International Symposium on the Total Risk and Benefit Impact of Energy Alternatives, held at the University of Waterloo in 1986.

Despite the long delay in publishing these proceedings most of the papers are still relevant – the problem of evaluating the risks and benefits of various energy sources is still with us. Many deal with nuclear energy, with almost all showing that the risk is small. There is a group of papers on risk management and some on that perennial question of risk perception. The last essay may induce a nod of agreement from many in the nuclear field with its argument that just because an activity presents a risk less than that from other accepted activities does not mean that it will be "acceptable."

Officers' Seminar

Approximately once a year the CNS Council holds an "Officers Seminar" to which the chairmen and representatives of the branches are invited.

This year the Officers Seminar was held in the morning of September 17 followed by a Council meeting in the afternoon. As well as reviewing branch activities and exchanging ideas the meeting also included discussion of a number of topics of general interest.

Finances

Treasurer Keith Bradley provided the reassuring news that the Society is quite solvent with a very healthy balance, largely attributable to profits from seminars organized by Society members. The Council extends, on behalf of all members, deep appreciation to those relatively few members that have contributed so much time and effort to make CNS events so successful.

A representative of the Society's investment firm provided some background on the GST. The CNS has the option of registering or not and Council is considering the advantages and disadvantages.

Communications

All present recognized the need for good communication with the public. There is an education fund which can be drawn upon for appropriate projects. The Chalk River Branch cooperates with AECL in presenting an annual "science for educators" seminar while the Toronto Branch holds its public lecture series at the University of Toronto. Jim Brown, chairman of the Public Affairs Committee, reported on a program for "Educating the Educators" that is being developed by his group.

In a related group Ken Talbot noted the FEARO hearings on AECL's waste disposal concept and urged branches to participate. (See separate article). The CNS has decided to present a brief to the Ontario Environmental Assessment Board's hearings on Ontario Hydro's demand and supply study.

International

Ken Talbot reported that discussions are proceeding towards formal agreements with the European Nuclear Society and the newly formed Nuclear Society of the U.S.S.R. There is also a move towards the creation of an International Nuclear Societies Council as a further formalization of the International Nuclear Societies Group. (See comments by the President).

Branch Activities

New Brunswick

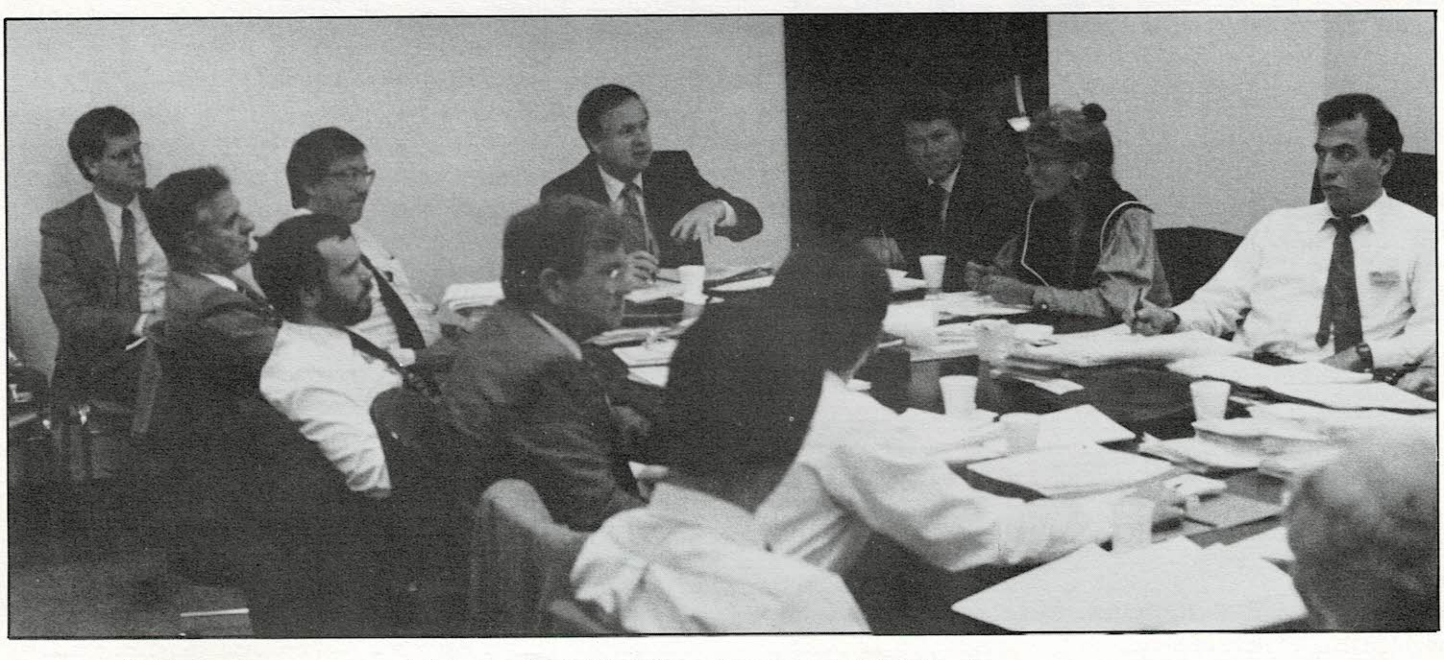
The active New Brunswick branch had a successful year under chairman Roger Steed and his executive. The first speaker of this fall's series of meetings was Keith Weaver with his views on "accidents and errors". In mid November the branch hosted a meeting of the Council, preceded the night before with a dinner meeting at which President Hugues Bonin spoke on the use of thorium in CANDU reactors.

The New Brunswick branch sponsors an essay contest on the "environmental impact of electrical generating options", with $100 top prizes in both French and English.

Chalk River

Because of the number of technical lectures at CRNL the Chalk River branch does not hold as many talks as other branches. Nevertheless, in December the branch will be co-sponsoring a talk by Dr. Bernard Cohen of the University of Pittsburgh on "Risk and Risk Aversion in Our Society."

Last spring the branch participated in the 3-day Annual Science for Educators Seminar sponsored by AECL-CRNL.



Treasurer Keith Bradley makes a point during the CNS Officers' Seminar, September 15.

Ottawa

Ed Waller, of SAIC Canada, has taken over as chairman from Terry Jamieson. Meetings are planned to be held approximately monthly, typically late afternoon of the third Thursday, in the Bytown Officers Mess.

In October, Gordon Sims, author of "The Anti-Nuclear Game" spoke about some of the problems and incidents associated with preparing the book and, especially, with interviews and debates since its publication. Scheduled for November 29 is David Mosey, author of "Reactor Accidents".

Central Lake Ontario

Chairman Dan Meraw reports that a talk by Dr. J. Paquette of CRNL on "Cold Fusion" in June brought the 1989-90 season to a close on a very successful note. The first event this fall was a tour of Zircatec Industries in Port Hope. Zircatec manufactures fuel and liquid zone control assemblies. A luncheon meeting with a talk on the Japanese heavy water program was scheduled for November.

Toronto

The large Toronto branch, chaired by Ben Rouben, cosponsors, with the Centre for Nuclear Energy, a public presentation series of lectures at the University of Toronto. In September Bob Stasko of CFFTP spoke on "Fusion Power in the Next Century" and in October Egon Frech of AECL-WNRE, presented a picture of the current FEARO review of AECL's deep geological disposal concept for used reactor fuel. Dr. Kenneth Hare is slated to speak on the "Future of Nuclear Power Safety" on November 27.

Golden Horseshoe

This Hamilton based branch also holds meetings approximately once a month, typically at McMaster University. Planned speakers for this year include Dr. M. Srinivasan of the Bhaba Research Centre, Bombay, India and Dr. P. Lemoine of Electricité de France.

The branch was involved in the McMaster Symposium on Nuclear Science and Engineering held in early October.

Saskatchewan

The Society's newest branch, located in Saskatoon, is closing its first year in an optimistic frame of mind. In late October, Gil Phillips, of the Canadian Fusion Program, was the speaker at a dinner meeting. The November meeting is scheduled to coincide with the FEARO hearings on nuclear fuel waste disposal concept.

News of Members

John Graham, director of Licensing for AECL Research, has been nominated for vice-president / president-elect of the American Nuclear Society. Under the ANS system the vice-president automatically moves on to the presidency.

Graham, who came to his present position in 1988, divides his time between Ottawa, where he resides, Chalk River and Whiteshell. He is an active member of both the Chalk River and Ottawa branches of the CNS.

The only Canadian to become president of the ANS was Dr. W.B. Lewis back in the mid-1960s.

CNS Writes to Ontario Premier

Hoping to influence the Ontario government before it presented its program in the Speech from the Throne, November 20, the CNS Council decided to write to Premier Robert Rae. Following is the text of that letter.

Use of Nuclear Energy in Ontario

Dear Mr. Rae:

I am writing to you on behalf of the more than 400 Ontarians and 200 other Canadians who are members of the Canadian Nuclear Society. We are the men and women engineers, scientists and other professionals who represent the "human face" of nuclear technology in Canada.

First, please accept our congratulations on the election of yourself and your party to a majority in the legislature. You have clearly communicated your adherence to principle in government and we look forward to the impact this will have on the quality of public decision making in this province.

In this regard, we are concerned that the New Democratic Party's stated policy of phasing out the use of nuclear energy in Ontario be presented for implementation in a manner which permits a full and public review of all of the relevant issues before any decision of the legislature or the government which might preclude future options.

The CANDU nuclear industry has been built up over the last forty years as a result of the dedication and commitment of many intelligent, socially concerned and caring Canadians, our members included. We have pursued this technology not just because it provides well paying jobs and interesting technical and scientific challenges, but because we believe that, based on a thorough and intimate understanding of risks and benefits, nuclear power is one of the most environmentally benign, economic and sustainable energy technologies available to mankind. It is one which can continue to support the standard of living which Ontarians and other Canadians enjoy and to which all human beings legitimately aspire.

We, as sisters, brothers, mothers, fathers and grandparents of young Ontarians, would not work in this industry if we did not have these beliefs.

Our industry is complex. It relies on a truly marvellous structure of interrelationships, trust and understanding between institutions, companies and individuals in Canada which have allowed us, with our small industrial base, to compete with the handful of nations able to offer a viable nuclear power system. An anchor in that structure has been the continued reliance of Ontario Hydro on CANDU reactors for its base load generating capacity, consistent with its mandate to provide power to the people of Ontario at the lowest achievable economic and environmental cost.

The rejection of CANDU as an option for Ontario could very quickly destroy the fabric of the Canadian nuclear industry, most of which is centred in this province. In such events, it is not conceivable that it could be resurrected at a later date. If we returned later to the use of nuclear power, it would be based on technologies generated and controlled in other countries, without the unique features of CANDU which have served our province so well to date, including its high local content.

We are acutely conscious of the honestly held fears and apprehensions which many citizens have on the issue of using nuclear energy. Appropriate forums can and are being established for these to be addressed in an open, honest and comprehensive manner, as they have been in the past. But fear should not form the basis for deciding the future of a major and vital Ontario industry.

The Council of the Canadian Nuclear Society earnestly adjures you to approach this issue in a manner which will maintain the CANDU option for Ontario and for Canada, at least until an open and informed decision can be taken on the basis of considered facts and the true interests of our citizens. We propose that the presently planned Environmental Assessment Board hearings on Ontario Hydro's Demand / Supply Plan is an appropriate forum to consider, in a most comprehensive manner, available energy options and recommend a policy with respect to the use of nuclear energy in Ontario.

Further, we respectfully urge you to instruct Ontario Hydro to take no action in the meantime which would have the effect of precluding future options for utilizing CANDU nuclear technology.

Yours very truly,

Hugues W. Bonin
President

What Throne Speech Said

Following is the section of the Speech from the Throne to the 35th Parliament of the Province of Ontario that deals with the environment and energy.

The Environment

There is an environmental crisis facing Ontario and it will require an extraordinary effort to meet it. We accept our duty to the future. We will need to assess our decisions not only by standards of social justice or economic growth, but in terms of their ecological integrity. We know that we cannot have a healthy economy without a healthy environment. A sustainable economy will provide added opportunities for new jobs, which will last into the future, and which will enhance, rather than harm, the environment. Our environment is more than the natural landscape. It is our individual health and well-being. It is our children's future.

We can no longer afford to be a throw-away society. We must recognize that most garbage is used material which still has a value to society. We must expand and enhance our efforts to Reduce, Reuse and Recycle solid waste. The previous government established the objective of twenty-five per cent waste diversion by 1992. Without tough measures, we will not meet that objective.

Our province's southern boundary touches all of the Great Lakes. These magnificent bodies of water have for too long been treated as waste dumps. We will act to protect our supply of clean water. We will conserve and manage this precious resource and the watersheds that support it. As a first step, we will introduce a Safe Drinking Water Act to set standards for water treatment and protect our people's health and safety.

Many of our roads are becoming too congested to work effec-

Members of CNS Council receive an introduction to AECL CANDU's CAD system, following the council meeting of September 15.

tively. My government is committed to a program of expanded public transit, not only to help the movement of goods and people but as a strategy for improving the environment and the economy.

Nowhere is the link between the environment and the economy more evident than in forestry. In the past few years, our forests have been a cause for concern when they should have been a source of pride. We believe in sustainable forestry, and are determined to see that our forests are regenerated.

We believe that people have the right to seek legal action to redress environmental harm. We will introduce an Environmental Bill of Rights in this session. We will seek the advice of the public on the specific details of the bill. This legislation will be an important step in giving individuals more control over the quality of their environment.

Energy

My government is proud to announce new energy directions for Ontario to protect the environment while ensuring that the province continues to have a reliable supply of energy at reasonable prices.

We plan to complete construction of Darlington and to bring the station into operation. This will provide the security of electricity Ontario needs for the immediate future. The Environmental Assessment Board hearings on Ontario Hydro's twenty-five year demand and supply plan will continue. This will provide an opportunity for an independent evaluation of the economic, social and environmental aspects of all options, including conservation, for Ontario's electricity future.

Meanwhile, we will instruct Ontario Hydro to intensify its efforts and its investment in energy conservation. To that end, we will place a moratorium on new nuclear power facilities. We will ask Ontario Hydro to divert planned expenditures for new nuclear development towards the most comprehensive energy conservation and efficiency program ever undertaken by a utility in North America. These efforts to use energy more efficiently will also assist in reducing global warming. These new energy directions will be a challenge to all citizens of Ontario to take part in individual and community efforts to ensure the most efficient and environmentally sound use of our energy resources.

Calendar

Meetings

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**, c/o (416) 977-7620.

12th Annual Meeting of the Canadian Radiation Protection Association

To be held **June 16-19, 1991,** at the Fort Garry Hotel, Winnipeg, Manitoba, in conjunction with an international radiation protection symposium, June 20, and followed by meetings of three other related societies. Abstracts are still being accepted – contact: **Irv. Gusdal**, (204) 474-9290.

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.

International Conference on Design and Safety of Advanced Nuclear Power Plants

Co-sponsored by CNS, to be held **October 25-29, 1992** in Tokyo, Japan. For information contact: **Prof. Yoshiaki Oka**, The Institute of Applied Energy, Tokyo. TeleFAX 81-3-501-1735.

Calls for Papers

12th Annual CNS Conference

To be held **June 9-12, 1991** in Saskatoon, Saskatchewan. For information contact: **A.L. Wight**, Ontario Hydro, Tel. (416) 592-7285, Fax (416) 592-9106. **Deadline for summaries – 17 December 1990.**

1991 CNS Simulation Symposium

To be held **August 26-27, 1991** in Saint John, New Brunswick. For information contact: **P.D. Thompson**, Point Lepreau GS, Tel. (506) 659-2220, Ext. 234; Fax (506) 659-2703. **Deadline for summaries – 31 January 1991.**

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

To be held **September 29 - October 4, 1991** in Albuquerque, New Mexico, USA. For information contact: **John Bartlit**, Los Alamos National Laboratory, Tel. (505) 667-5419; Fax (505) 665-1687. **Deadline for summaries – 15 February 1991.**