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Editorial

The Politics of Food Irradiation

Food irradiation has become the topic of the moment. A number of items have appeared recently on it, in the press, as reviews and scientific reports and in other formats. Some of the press reports have betrayed such an appalling technical illiteracy that to ignore them would be the greatest kindness one could show their authors. In what follows, that kindness will be proffered and attention directed instead to two reports of particular significance: a Discussion Paper published by the Science Council of Canada entitled "Issues in Food Irradiation," and the report by the Standing Committee on Consumer and Corporate Affairs, entitled "Food Irradiation."

Before commenting on either of these reports, it may be as well to make the ground rules absolutely clear. First, there should be no question that we all agree with attempts to ensure that our food supply is safe and nutritious. This is so obvious as hardly to need stating but it is as well to have it on record. Second, it is to be expected that any commentary appearing in a publication of the Canadian Nuclear Society about the societal aspects of nuclear matters, may face the criticism that it is biased. There is no point in denying this and no harm in stating it. People in the nuclear industry are not free of bias. Anyone who works closely on a topic for years or decades is bound to have a commitment to it and to understand it differently from someone who hasn't had this detailed exposure. Consequently, people whose job it is to study, to sequester and to apply to useful ends, radioactive materials and their effects, will likely not share with the man in the street the same apprehensions nor draw the same conclusions about the implications of some new technique or application.

Having declared that there is nothing up our sleeves, and that we should be viewed as normal people with a particular area of expertise rather than as untrustworthy prestidigitators, we can turn to the two reports.

The report by the Science Council is a semi-technical review signed by its author. The stated purpose of the document is two-fold: "to raise public awareness of food irradiation" and "to help build consensus among government and private sector decision makers about what has to be done to realize the domestic and export potential." In the course of meeting these two goals, the potential, methods, uses, safety and nutritional aspects of food irradiation are reviewed, along with some international commercial developments and how things are unfolding domestically. The review appears to be complete and many of the points discussed include references to other documents or studies. A detailed critique of the document could readily be made by a food irradiation expert, including the adequacy of its coverage, the goodness of any judgements it has arrived at, how well it has flagged areas where there are problems or uncertainties, etc.. Perhaps most important, the review seems to be a reasonable introduction to the subject for the non-specialist, providing numerous points of entry to the more detailed technical literature through the references.

The report of the Standing Committee is less straightforward. It should be obvious that the Committee members can be expected to share the same commitment to safe and nutritious food that any normal person would have. Equally, it should be evident that the Committee is not free of political bias. The origins of such bias could never be entirely clear to someone on the outside, since many issues press upon politicians at any one time. Furthermore, it is unlikely that politicians would actually undertake to identify and articulate those factors that they thought were influencing them most. Therefore, one should find no difficulty in accepting this report as a "political" document, vague as the adjective may be. Nor should it come as a surprise to find the Committee members perched in safety upon the fence on some issues, on a fence that already groans under the weight of those multitudes who hope to be seen leading from the rear.

However, even political documents should be able to meet a few criteria. Such documents should at least demonstrate skill and subtlety in the ability to skate and to confuse issues. They should be written in a readily understandable form and if they do not observe the facts they should at least not flout them blatantly. If they invoke any specialized disciplines, they should either leave any technical interpretations to specialists or at least identify clearly which works or publications of which specialists they are relying on for their interpretations.

Safety of the Consumer?

Turning now to the Standing Committee report and looking at it from some of these perspectives, one beholds a dismaying picture. The following comments will concentrate on Chapter 1 of the four chapters of the report. This chapter is perhaps of most interest since it discusses "Wholesomeness and Safety of Irradiated Food" and formulates 13 of the 33 recommendations in the report. (The other chapters cover Labelling of Irradiated Food, Technological Considerations, and Comments and Recommendations on an earlier Information Letter by Health and Welfare Canada.) The first chapter begins ominously enough by stating:

"The concern that has been expressed about the safety of ingesting irradiated foods appears

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to be derived from the negative perception of nuclear safety, particularly when nuclear technology is associated with food; a fundamental of life. To a considerable degree this association has been strengthened since the Chernobyl accident in 1986 that resulted in widespread radioactive contamination of food."

In the next paragraph, it is stated

"The Standing Committee is of the view that these concerns are warranted...".

What does this mean? Does it mean that the Committee agrees that the public has good reason to fear whatever dastardly things food irradiation might do to their food? Does it mean that they regard the supposed connection between nuclear accidents and food irradiation to be real and to be guarded against? Does it mean that the public is concerned and deserves to be informed if this concern arises out of ignorance? Alas, we aren't told, but out of the mangled collection of fact and fantasy, the Committee somehow draws the conclusion:

"The introduction of any food technology or additive must therefore, be assessed first on the basis of concern for the safety of the consumer."

Surely this could have been stated as a given, without all the pirouetting and obfuscation.

Potential Risks

Earlier, in the Introduction, the report states that

"...decisions on whether to proceed [*with food irradiation*] *when factors are many and complex require analyses of both the potential benefits and the potential risks."*

Throughout Chapter 1, many such "potential risks" are identified. These include the concern that some of the toxicological studies done in the past do not meet current standards, the apparent increase in polyploidy among malnourished children in India who were fed irradiated wheat, the question of whether radioactivity can be induced in food by the irradiation process, the effects that may arise due to the production of free radicals and radiolytic products by the irradiation process, the possibility that harmful by-products may result from the irradiation of pesticide residues, the possibility that bacteria which produce botulism toxin may survive the irradiation process, the possibility that Salmonella micro-organisms may become resistant as a result of irradiation and the prospect that irradiation might affect the appearance and flavour of some foods adversely. In fact, the Committee has gone out of its way to enumerate every potential risk it could identify, as it should do. However, it has completely abandoned all sense of proportion in doing so. First, there is no mention of the benefits of food irradiation, or even that there are benefits. If there were no benefits and only risks, the Committee should have recommended that no food irradiation be allowed under any circumstances. This the Committee has not done, so it must recognize that some benefits exist but chooses to do the public, and the government, the disservice of not mentioning them. No judgements are brought to bear on the nature or seriousness of the potential risks that are identified; no expert testimony is adduced to indicate whether the potential risks are present or remote, whether the problems posed by them are matched with solutions in hand, or proposed, or if no solutions are in sight. In fact, the Committee seems to have abdicated its responsibility for giving clear-thinking advice and donned instead the mantle of the fear monger. Second, in agreeing that food should be "safe," the Committee appears to interpret safety as an absolute. We need more research because there are still outstanding problems that we don't fully understand. How many fertilizers, pesticides, or industrial chemicals would survive a similar scrutiny? After all, these products find their way into the air we breathe and the water and food we consume, all of them "fundamentals of life," to use the Committee's phrasing. What are the dose-response curves for these thousands of compounds and what are the long term effects of exposure to them at low levels? The suggestion here is not that one should gloss over any uncertainties or difficulties in food irradiation, but that one should recognize that perfect knowledge is a chimera and get on with the entirely practical business of making reasonable judgements and decisions. The approach used by the Committee is just the knee-jerk equivalent of another time-honoured political expedient to be applied when one finds oneself in deep water: call for a Royal Commission and hope that it takes its time.

Credibility Questions

These criticisms are all serious enough. But the aspect of the report of greatest concern for anybody who works as a specialist in a specialist field, and probably the most damning criticism and the gravest flaw in the report is that it appears to be masquerading as a document that carries some technical weight, has the trappings of scientific merit. Some examples will demonstrate this.

On the issue of polyploidy and free radicals, the Committee's report states:

"According to the 1986 [*report*]*...by the U.K. Advisory Committee on Irradiated and Novel Foods (ACINF) free radicals can remain in bones for several years. It is therefore possible that free radicals caused the polyploidy effect from ingesting freshly irradiated wheat. These possibilities pose difficult scientific questions which require further investigation..."*

Since no sources are cited to support this conclusion, one has no way of knowing whether it was formulated by the Committee, whether it is the view of a member of the general public who made a submission to the Committeee, whether it is expert advice that they are relying on, or indeed whether it is the consensus of workers in the field. One clue is available from the Science Council report. In that report the author quotes from the same U.K. Advisory Committee report which states that:

"there are no toxicologically significant qualitative differences between the radiolytic products ...and the products in conventionally processed foods, and that the chemical changes produced by irradiation of food are usually less than the changes found in foods processed by conventional methods whose safety is accepted."

Which is more reliable? A conclusion about the mechanisms causing a chromosomal irregularity, apparently drawn by non-specialists and apparently based on the poorly referenced citation of one specific detail from a specialist review? Or the direct citation of a more general conclusion from the same specialist review in another review prepared by a working scientist? Most specialists would probably be eager to have the Committee clarify this question. And it is indeed of interest to all specialists because it may be anyone's field of endeavour that is in line for similar treatment by some future Committee.

A second, and similar, example relates to the question of Salmonella resistance. On this point the Committee's report states

"...Salmonella have shown a remarkable ability to adapt to antibiotics and develop resistant strains. It is likely that irradiation would provide a similar if not accentuated selection pressure for the development of resistant Salmonella strains."

Once again, the vagueness of the presentation completely obscures any message. Does this mean that irradiating food would make Salmonella bacteria more resistant to antibiotics, or confer such resistance more quickly? Does it mean that the Committee fears that Salmonella will eventually become resistant to irradiation, that the atoms and molecules of these organisms may somehow fail to be ionized by ionizing radiation after some period of expo-

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sure? Whatever the Committee means by this statement, the comments of the previous example apply. What is the source of their conclusion? Is it the view of experts, and if so, which ones? Or is it just some speculation that the Committee has come up with?

Still on the subject of Salmonella, the Committee cites a study which ranks food irradiation sixth out of eleven on a cost-effectiveness basis as a means of controlling Salmonella. Some of those that beat out irradiation, as reported by the Committee, are educating the home-maker, educating the food service sector, the use of chlorine dioxide in poultry packing plants, and measures to clean up the poultry processing industry. In passing, the Committee notes the views of an unidentified food scientist who feels that the use of food irradiation may give the consumer a false sense of security and promote poorer food handling techniques.

Statements like this are enough to take one's breath away. Any measures of cost-effectiveness depend on one's assumptions concerning both the cost and the effectiveness. The Committee's recommendation to pursue methods of dealing with Salmonella that are more cost-effective than food irradiation (a recommendation which immediately follows this example in the report) seems to depend on this one quoted study. The assiduously pursued scrutiny of the potential pitfalls of food irradiation shown in the Committee's report is strangely at odds with the alacrity and trust with which they seem to embrace the cost-effectiveness conclusions of one report. Educating the home-maker was one of the "more cost-effective" solutions to the Salmonella problem. Quite apart from the fact that some combination of methods may be of lower cost and be more effective than any one of them alone, alarming chinks can be seen in the Committee's logic here, even by one who is only marginally sighted. For example, if the public is so fickle that they can be coaxed into bad food handling habits by the use of food irradiation, won't the same thing apply to any other technical fix to the Salmonella problem, short of eliminating the Salmonella bacillus altogether? If the public is that fickle and inconstant, how much faith could a responsible authority conceivably place in a public education program?

The Bottom Line

Viewing the Science Council report and the Standing Committee report side by side serves to display the grotesque shortcomings of the latter report in sharp relief. It is not only a bad report, misleading to the public who financed it and unworthy of the institution that generated it; the Standing Committee's report is also an appalling and frightening document. Appalling because it is scientifically unsound, logically inconsistent, shamefully incomplete and an unmitigated travesty of the use of specialist data in coming to a political conclusion. Frightening, because it may be an indication of the depth and quality of thought by politicians that goes into regulatory and approvals decisions affecting one of the things most important to everybody: our food.

Perspective

Nuclear Regulation

Adapted from a paper by Jon Jennekens presented at the 1987 Canadian Engineering Centennial, May 18-22, 1987, in Montreal.

Regulation – A Primary Function of Governments

It is accepted by most Canadians that the enactment of laws and the promulgation of regulations and their subsequent administration constitute a primary function of governments. The law known as the Atomic Energy Control Act[1] was passed in 1946 to declare atomic energy to be a matter of national interest, to make provision for the control and supervision of the development, application and use of atomic energy, and to enable Canada to participate effectively in measures of international control which might thereafter be agreed upon. It is indicative of the wisdom and foresight of the federal lawmakers of 1946 that except for a single amendment of the Act in 1954, which separated the regulatory and developmental responsibilities for atomic energy between the Atomic Energy Control Board and a Minister designated by the government, and certain consequential amendments resulting from other legislation, that the Atomic Energy Control Act has remained substantially unchanged over more than four decades.

Parliament's decision to use the word "control" in the title of the Act, in its preamble and in several of its sections including the title of the body corporate established to administer the Act, was not by chance. The word control then and today provides little room, if any, for argument as to its meaning. The Act is essentially skeletal legislation which gives the Atomic Energy Control Board (AECB) the extensive discretionary powers considered by Parliament in 1946 to be essential to the national interest. Today such broad discretionary powers are seldom delegated to a creature of government. In fact, one of the most important functions of the Standing Joint Committee of the Senate and of the House of Commons on Regulations and other Statutory Instruments is to identify any actual or proposed exercise of substantive legislative power or discretionary authority which should properly be reserved for Parliament. However, the events of 1945 had led to the unmistakable conclusion that strict controls and supervision of atomic energy developments were required and that strong, enabling legislation should be enacted.

The Minister of the Crown responsible for introducing the proposed legislation was the Honourable C.D. Howe, a professional engineer of considerable competence. His recommendation to the Prime Minister to appoint another well-known engineer and inventor, General A.G.L. McNaughton, as the first president of the AECB reflected his view that engineering expertise would be needed in the development of the necessary controls.

Today, engineering expertise is one of the many scientific and technological inputs into the Canadian nuclear regulatory process.

The Meaning of Regulation

For almost a century, Black's Law Dictionary[2] has served as one widely used authoritative guide to the legal meaning of standard English words. The substantive part of Black's definition of regulation is "rule of order prescribed by superior or competent authority relating to action of those under its control". At a time of growing debate over whether or not Canadian society is subjected to excessive or unnecessary regulation, Black's definition provides considerable insight as to the crux of the debate.

Although most Canadians object at one time or another to the various controls imposed upon them by governments, careful reflection invariably reveals that this same majority of Canadians look to governments regularly for protection, assistance or action to remedy an injustice. In many instances, what critics of government are unhappy about is not the fact that regulation occurs but the manner in which it occurs. It is all too often the administration of regulations or the regulatory process which is the source of dissatisfaction. It is in this context and in the context of Black's words "...rule of order prescribed by superior or competent authority..." that the following description of the Canadian nuclear regulatory process has been prepared.

The Canadian Nuclear Regulatory Process

The AECB controls and supervises the development, application and use of atomic energy by making regulations and by an extensive licensing system that addresses the aspects of public and occupational health and safety, physical and personnel security and environmental protection which are associated with the use of radioactive substances and equipment and the operation of nuclear facilities. The licensing system is implemented in consultation with other federal and provincial departments and agencies. Indeed, federal-provincial cooperation in the implementation of the nuclear regulatory process has been invaluable. The AECB's control system extends to the import and export of nuclear materials, equipment and facilities and is one of the mechanisms by which Canada fulfills its obligations to the International Atomic Energy Agency (IAEA) assumed pursuant to Canada's ratification of the Treaty on the Non-Proliferation of Nuclear Weapons (NPT).

The Regulations made under the Atomic Energy Control Act require that any person or organization wishing to produce, mine, refine, process, sell or use radioactive substances or equipment or to construct and operate a nuclear facility obtain a licence from the AECB. The Regulations place the onus on the licensee to show that his activities will be or are

being done in a safe manner. In considering licence applications the AECB calls for information sufficient to show that all relevant health, safety, security and environmental protection standards will be achieved and maintained. These standards have been developed over the past forty-one years in close collaboration with individuals and organizations who represent the entire spectrum of activities involved in the manifold peaceful uses of atomic energy. The nuclear standards development process in Canada is characteristic of the consensus standards approach which has been such a vital factor in almost every societal endeavour involving scientific and technological means of serving the public interest. It is a process which has been characterized by continuing efforts to ensure that competence regardless of its source is recognized and utilized. Thus, the expertise of practitioners, be they in the fields of scientific or industrial research, or the development or application of atomic energy, is brought to bear in the standards-making process.

In addition to the many interfaces which the AECB has with national and international authorities and advisers, the Board is served by two independent advisory committees: the Advisory Committee on Radiological Protection and the Advisory Committee on Nuclear Safety. These two standing advisory committees are composed of nationally and internationally recognized experts in the field of medical science, the natural sciences and engineering, and many other learned professions. The Committees advise the Board on generic issues requiring a multidisciplinary approach in addressing all nuclear safety and radiological protection aspects of the peaceful uses of atomic energy and ionizing radiation.

The Fundamental Principles of Canada's Nuclear Regulatory Approach

The basic approach adopted by the AECB in its control over atomic energy developments in Canada has evolved in concert with the evolution of Canada's nuclear industry. The underlying principle which has governed this approach is that primary responsibility for achieving high standards of nuclear safety, security and environmental protection in the use of radioactive substances and equipment and in the design, construction, commissioning, operation and decommissioning of nuclear facilities rests with the licensee. The Board views its role as standard setting and ensuring that licensees live up to their responsibilities.

To state that the licensee bears primary responsibility for achieving and maintaining high standards of nuclear safety, security and environmental protection may be regarded by some persons as an attempt by the regulatory agency to evade its responsibilities. Most persons conduct their affairs in a proper manner not because there is a law telling them to do so but because it is the appropriate thing to do. This is equally true of corporations notwithstanding the need for regulations which set the standards to be met.

A complementary and equally important reason for insisting upon the need to recognize the primacy of the licensee's responsibility arises from the conviction that those persons proposing to conduct an activity in the atomic energy field, or for that matter in any field of human endeavour, should be more knowledgeable about the activity than the regulator. If this is not the case, then the control action required for the proposed activity is simply one of prohibition. A prerequisite for the issuance of a licence to construct and to operate a nuclear facility is the judgement by the AECB of the necessary design, construction and operating competence on the part of the applicant. Continuing demonstration of such competence is an essential aspect of the AECB's ongoing requirements.

A second fundamental principle of Canada's nuclear regulatory approach is that regulatory criteria and requirements should be concise, clearly stated and understandable. Thus, the Canadian approach has been to establish these criteria and requirements in accordance with the standards-making process outlined earlier and then to examine, assess and evaluate licence applications against them.

Typical of the regulatory criteria developed from the evolving Canadian nuclear safety approach are those applied in evaluating the design of nuclear facilities. These criteria emerged as designers, operators and regulators alike reviewed past experience with early research facilities, examined the principles and practices followed in other advanced technologies such as the aerospace, communication and computer technologies, and assessed the results of ongoing research and development programs. The criteria became accepted as design, operating and regulatory criteria in a joint process quite unlike that of some other countries.

A third fundamental principle of Canada's nuclear regulatory philosophy is that fairness and impartiality must characterize all regulatory decision-making. It is evident that the achievement of fairness and impartiality is no simple task. There are many sectors of society to be addressed in achieving this objective and it is equally evident that their respective views are far from synonymous. An applicant for a licence, be it a general hospital with a nuclear medicine department or a small industrial radiography company, hopes that the licensing process will be simple, straightforward and inexpensive. A university researcher expects that there will be a minimum of paper burden and essentially zero delay. A foreign company wishing to export or import nuclear materials or equipment rightfully expects that the regulatory process will be easily understood, conform to established legal and administrative practices of the host country and will be conducted in a cooperative, non-discriminatory manner.

The Public Interest – The Meaning of the Term

In endeavouring to fulfill its responsibilities to the people of Canada, the AECB has been very conscious of the many dimensions of the oft-used term "the public interest". It has recognized and regularly reaffirmed its long-standing view that its responsibilities form a small albeit very important subset of the entire set of individual interests which constitute the broad public interest. The AECB has understood its mandate to be the control and supervision of the development, application and use of atomic energy in a pragmatic, scientifically and technically correct, effective and efficient manner in conformity with the overall policies of the federal government. It has recognized from the outset the tremendous potential which atomic energy holds for both good and evil and therefore its national and international roles have been pursued with vigour. The AECB has long realized that its controls must not unnecessarily impede the development and application of the many peaceful uses of atomic energy while ensuring conformance with required standards. Similarly, the AECB must weigh very carefully the interventions made by proponents and opponents of various applications of atomic energy and ionizing radiation and exercise judgement in its regulatory decisions. While maintaining the view that nuclear regulation is and will continue to be a necessary and important function of government, the AECB has recognized that its controls must avoid undue or unjustified interference with the rights and freedoms of any person whose activities are subject to nuclear regulation or those who might be exposed to radiation risks from such activities.

The Public Perception of Risk

In a 1925 article about the unknown hazards of radio broadcasting,[3] Clarence Purssell stated: *"During the past three or four years much has been said about radio in its various branches ...little, however, has been brought to the attention of the public dealing with hazards which may be encountered either through ignorance or negligence and certain precautions that are necessary to the protection of life and property."*

Today, Purssell's concern about the potential hazards of radio broadcasting would likely be treated with derision if even noticed or mentioned in the ongoing debate over the risks and benefits of atomic energy. Needless to say, the series of human and equipment failures which began on March 28, 1979, at the Three Mile Island Nuclear Power Station and the much more disastrous series of human failures which began on April 26, 1986, at Chernobyl have added considerable energy to the debate over nuclear power. Prior to the failures at Three Mile Island, the AECB initiated a staff study[4] to compare occupational and public risks arising from the generation of electricity from conventional energy sources (coal, oil, natural gas, water and uranium) and the alternative or non-conventional sources (solar, wind, ocean thermal and methanol). The initiative was taken as a result of repeated representations from some members of the general public, special interest groups, members of Parliament and Provincial Legislatures and the media. The principal conclusion of the study was that both public and occupational risk from the so-called "soft energy" or non-conventional sources can be as high as or higher than that of conventional sources. In particular, the study showed that the risks

posed by nuclear power were from 10 to 100 times lower than that posed by some non-conventional sources.

The demands by various persons for the AECB to carry out such studies all but ceased in the ensuing debate and new demands calling for a reorganization of the AECB appeared. Although in the longer term Aristotle's admonition that "In practical life, particular facts count more than generalizations" will undoubtedly prevail, the generalizations which followed the Three Mile Island and Chernobyl failures clearly overshadowed the undeniable fact that Canada's nuclear regulatory standards have stood the test of time for more than forty years.

There can be no doubt that the public perception of risk is a complex matter which baffles the rigour of the scientific method in its analysis. Nevertheless considerable effort is underway throughout the world to shed further light on this subject.

References

1 Atomic Energy Control Act 1946, as amended. R.S.C. 1970, c. A-19.

2 Black, Henry Campbell, "Black's Law Dictionary", West Publishing Company, St. Paul, Minnesota, 1968, p. 399.

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4 Inhaber, Herbert, "Risk of Energy Production", AECB-1119/Rev. 2, November 1978.

FYI

Chernobyl Health Effects Studied

(IAEA Newsbriefs)

Scientific and medical knowledge about long-term health effects from exposure to low doses of radiation promises to benefit considerably from an extensive Soviet study being done in response to the accident at Chernobyl, in the view of international experts who attended a workshop on the topic in Vienna recently. Jointly organized by the IAEA and World Health Organization (WHO) from 18-22 May, the workshop brought together 25 experts from 10 countries.

The study would be "one of the largest and most complex epidemiological investigations ever undertaken," said the workshop's chairman, Prof. A. Kellerer of the University of Würzburg in the Federal Republic of Germany at the concluding press converence on 22 May. In commending the USSR's commitment to the systematic investigation, Prof. Kellerer emphasized international scientific co-operation, saying it would be important to develop and strengthen global ties by working with other institutes, notably the Radiation Effects Research Foundation at Hiroshima, Japan, both for purposes of exchanging results and to resolve problems that inevitably will arise.

Dr. Yuri Saurov, Professor of Medical Science at the Institute of Biophysics in the USSR Ministry of Health and one of three Soviet participants at the workshop, told the press conference that the study will monitor the health of more than 100,000 people who lived inside or near the 30-kilometre evacuation zone set up shortly after the Chernobyl accident. Monitoring of individual cases would last for 50 years or longer, he said. To conduct and co-ordinate the study, he said a national Scientific Centre for Radiation Medicine has been set up in Kiev, and that work has started on compiling a central registry for recording and processing health information for each individual case. The study will give priority to detecting health effects such as leukemia and mental retardation among children and, particularly, infants born after the accident.

The IAEA/WHO workshop was convened principally to provide an international forum for the provision of advice on appropriate studies and methodologies relating to the long-term effects of radiation in an exposed population. Further technical workshops are foreseen as part of international efforts to expand scientific knowledge and develop more detailed guidance in this important field.

Mining Hazards Compared

(Nuclear Energy)

The hazards involved in mining uranium have been a continuing source of criticism for the nuclear power industry.

These risks were examined quantitatively in comparison with the risks from coal mining in a paper presented at the Uranium Institute symposium in September 1986. The conclusion that the risk per unit of electricity generated is about 10 - 30 times greater for coal mining than for uranium mining makes an interesting contrast with some of the claims propounded in the nuclear energy debate.

The broad picture which emerges from the analysis is relatively simple. The risks of mining are rather similar per tonne of ore dug out of the ground. For a uranium ore grade of 0.1% the quantity of ore to be dug is 1000 times greater to give 1 t of uranium than to give 1 t of coal but the uranium gives about 20 000 times more energy per tonne than coal. With similar thermal efficiencies in coal-fired and nuclear power stations the ratio of mining risks per unit generated is thus around 20:1 in favour of uranium.

The detailed substantiation of this broad picture involves a complex evaluation of data for individual uranium mines with different ore grades, radiation exposures, accident rates and productivity. Some interesting points emerge from this detail.

The radon levels in open pit uranium mines such as Rossing are frequently lower than in UK coal mines. In all the mines considered, coal and uranium, the radon levels are less than in thousands of houses in the UK. However, the risks from mining are dominated not by radiation exposure but by the risks of physical accidents. By-product uranium from phosphates seems to be the safest source of all, since it not only requires very few staff but may also reduce the environmental hazard by reducing the quantity of uranium spread on the ground with fertilizer. Of the direct uranium mining technologies, in situ leaching involves the least risk, followed by open pit mining with underground mining having the highest risks.

The number of fatalities per gigawatt year is estimated to be in the range 0.005 - 0.03 for open pit uranium mines and 0.03 - 0.17 for underground uranium mines. For UK coal mines about 1.4 fatalities are estimated per gigawatt year. There is little doubt that for electricity generation it is safer to mine uranium than to mine coal.

Global Radiation Monitoring Program, Guidelines Planned

(IAEA Newsbriefs)

An inter-agency committee of specialized international organizations is planning ways to harmonize activities in response to accidental releases of radioactive substances into the environment. Organizations involved include the IAEA, Food and Agriculture Organization (FAO), Economic Commission for Europe (ECE), United Nations Environment Program (UNEP), World Health Organization (WHO), World Meteorological Organization (WMO), International Labour Organization (ILO) and United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR). The committee is part of efforts taken since the Chernobyl accident of April 1986 to improve international co-operation for post-accident prediction of environmental consequences, environmental monitoring capabilities and planning of countermeasures, and the exchange of information.

Although the committee is considering a wide range of topics for the long term, special attention is being given to:

- The need for comprehensive guidance to States on "intervention levels" upon which to base the introduction of protective actions, restrictions, or controls in the event of a radiological accident. Following the Chernobyl accident, extremely varied responses were adopted by national authorities.
- The need for an internationally co-ordinated radiation monitoring program. This embraces various possible tasks, including development of a global system for rapid data transmission; developing and strengthening national radiation monitoring capabilities; providing guidance on measurement methods and qualty assurance procedures; and harmonizing international activities in response to emergencies holding potential transboundary radiological consequences.
- Joint training activities related to radiation monitoring, emergency response and preparedness and radiation protection.

Formed as an *ad hoc* mechanism in September 1986 to address specific issues on a long-term basis, the committee has since met twice under IAEA auspices in Vienna, most recently from 23-24 April 1987. The next meeting is scheduled for September 1987.

CANDU 300 BOT Deal Proposed for Pt. Lepreau 2

(Nuclear Engineering International)

A CANDU 300 unit is being considered for the Point Lepreau station of New Brunswick Power. Discussions currently underway could lead to the start of construction in late 1987. Point Lepreau already has a CANDU 600 in service, and the site was designed as a multi-unit station.

A Build, Operate, Transfer (BOT) arrangement is being discussed between the federal and provincial governments, NB Power, and Atomic Energy of Canada Limited. Should the proposed arrangement mature, the CANDU 300 could be in service by mid-1993. A holding company would purchase, build and operate the unit. NB Power would buy the power at pre-arranged prices, consistent with the cost of power from a coal-fired unit. After some years of operation, the CANDU 300 could be transferred to NB Power ownership. Construction at Lepreau would be an ideal demonstration of the CANDU 300, which has never been built and which AECL is hoping will win it export orders. New Brunswick's power requirements cannot yet support another CANDU 600 unit, but more future power is required, hence the CANDU 300 proposal. The reactor is designed to be built for the same cost per installed MWe as the CANDU 600. Originally designed as a 325-375 MWe unit, design refinement has upgraded the CANDU 300 to 400 MWe net. The moderate capital costs and the financial arrangements of the holding company would allow power to be consistently sold at prices comparable to that from a coal-fired unit.

In designing the CANDU 300, AECL paid attention to minimizing capital costs, by reducing construction time, by standardization, and making provision for ease of maintenance and plant life extension. In particular, the cruciform site layout is designed to reduce the construction schedule by first building structures needed for reactor construction and other special on-site work.

Likely partners in the holding company are the governments of Canada and the Province of New Brunswick, and certain invited private companies. Federal support for the project, through the holding company, would only apply for a first demonstration of CANDU 300.

AECB Completes Review of Chernobyl Accident (AECB)

The Atomic Energy Control Board has submitted its report on the Chernobyl accident to the Minister of Energy, Mines and Resources. Entitled "The Accident at Chernobyl and Its Implications for the Safety of CANDU Reactors," the document reviews the accident and its causes, compares the Chernobyl and Canadian CANDU reactors, and discusses implications of the accident for the safety and regulation of power reactors in Canada.

The 50-page report, prepared by AECB staff in consultation with other Canadian agencies, concludes that the accident has not revealed any significant new information that would affect the current safety requirements for CANDU reactors. It was determined that all important aspects of the accident and its causes have been considered by the AECB in the licensing process for the currently operating reactors.

However, the authors make nine recommendations with respect to certain aspects of reactor safety that should be re-examined in order to reinforce their conclusion:

- The safety analyses of CANDU reactors should be re-examined by the reactor designers and operators to confirm that shutdown systems are sufficiently effective under all possible conditions. Particular attention should be given to events in which a rapid increase in the volume of steam in the fuel channels may occur, or in which there may be a rapid increase in reactivity.
- Various configurations of reactivity devices in CANDU reactors should be examined by the reactor designers and operators to ensure that it is not possible to put the reactor into a condition in which the shutdown systems might be rendered less than adequately effective. This should include an examination of the capability of the shutdown systems under conditions in which there are spatial variations in reactivity.
- The safety of the Pickering "A" reactors should be re-examined by Ontario Hydro and the AECB, particularly with respect to accidents involving failure of the reactor control system and loss-of-coolant accompanied by unavailability of the shutdown system.
- Station operating procedures should be re-examined by plant owners to ensure that they require and receive sufficient review by all pertinent and responsible personnel before tests on safety-related equipment are carried out or procedures for such tests are modified.
- The AECB and plant owners should review, and if necessary increase the frequency and extent of monitoring and auditing the performance of plant operators in complying with operating procedures, the Operating Policies and Principles, and the conditions of Operating Licenses.
- A study should be made by reactor designers and operators of the possible ways in which special safety systems can be disabled in CANDU reactors. These should then be reviewed to determine whether the design includes sufficient protection to prevent the disabling of safety systems without first obtaining appropriate management, and if necessary, AECB approval.
- Plant owners should review their on-site emergency procedures in the light of the Chernobyl accident to determine if the need for any changes is indicated.
- The recommendations of the Emergency Planning Department of the Ontario Ministry of the Solicitor General should be considered by all those involved in emergency planning both in Ontario and in other provinces where nuclear reactors are located.
- A review should be carried out by plant owners of fire-fighting techniques to determine how it would be possible to take measures to protect personnel from any radiation hazard which may occur simultaneously with a reactor fire.

The report is available from the AECB Office of Public Information, P.O. Box 1046, Ottawa, Ontario, K1P 5S9.

Bruce "A" Shut in May for Emergency Air Filter Retrofit

(Staff)

Ontario Hydro's four oldest reactors at the Bruce Nuclear Power Development were shut down for a month-long maintenance program last May. The reactors at Bruce Generating Station "A" were shut for a $2 million maintenance and upgrading project to a vacuum containment building. The aim was to improve its ability to prevent a release of radiation during an accident.

The project includes installing a new system that would filter air before it is released to the environment during a major incident, an Emergency Filtered Air Discharge System (EFADS). Also, the thick rubber seal between the building's roof and side wall, which is required to maintain the vacuum, was replaced. The entire containment system was reviewed during the shutdown.

SLOWPOKE Modification Extends Core Life (AECL)

Atomic Energy of Canada Limited has announced a simple modification for the SLOWPOKE-2 research reactor which extends the lifetime of the fuel by about 10 years. The development, says David Evans, Vice-President of Atomic Energy of Canada Ltd.'s Radiochemical Company at Kanata, Ontario, is a "significant contribution to the further development of SLOWPOKE-2 as a cost-effective reactor facility for university installations."

SLOWPOKE (Safe Low Power Critical Experiment) was designed as a source of neutrons for the production of radioactive isotopes and as an experimental and analytical tool for universities, hospitals and research institutes. It has become an important tool for trace-element analysis (analysis of a very small quantity of material of a sample). Its main features are low cost, inherent safety (it will shut itself down in an emergency) and simple self-controlled operation (it need not have an operator in attendance at all times).

The innovation basically involves more efficient use of neutrons produced in the core by using extra beryllium reflectors. Proposed by B.M. Townes, a Reactor Physicist at AECL's Chalk River Nuclear Laboratories, the innovation was implemented successfully at the SLOWPOKE reactor at Dalhousie University, Halifax, at the end of last year. The reactor was originally commissioned in 1976.

The Dalhousie reactor is one of five SLOWPOKE research reactors operating at Canadian universities; others are at the University of Toronto, Ecole Polytechnique in Montreal, Edmonton's University of Alberta, and the most recent at the Royal Military College,

TECHNICAL SUPPLEMENT

CNS Bulletin July/August 1987 Canadian Nuclear Society

EMERGENCY OPERATING PROCEDURES BASED ON THERMODYNAMIC STATE

Paper Presented at the CNS 8th Annual Conference,
June 14-17, 1987 in Saint John, New Brunswick

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ABSTRACT

Since the TMI-2 accident in 1979, all western countries with significant nuclear electricity supply programmes have recognized the benefits of a symptoms oriented approach for operator reaction and response to severe plant upsets.

The development of Emergency Operating Procedures (EOP) for the Point Lepreau station has followed a complementary two track structure, both tracks having a thermodynamic state basis. One track deals with plant upsets where the nature of the cause of the upset is recognized and an Event Specific EOP exists for that cause. The second track caters to upset conditions where

a) the Critical Safety Parameters are outside defined acceptable values or
b) the Critical Safety Parameters are trending towards their unacceptable limits and
   i) the cause of the event is not recognized or
   ii) the cause is recognized but no Event Specific EOP exists.

Event Specific EOP structure and format are discussed and illustrated and the Critical Safety Parameters associated with developing the second track for boiler heat sink configurations are discussed.

INTRODUCTION

The treatment of severe plant upsets has played a significant role in both operator training and Emergency Operating Procedure (EOP) development at Pt. Lepreau. Initially, prior to 1980, the application of a diagnostic or cause recognition approach was predominant in these programs. The diagnostic approach had been successful in other CANDU stations and was reinforced by probabilistic risk assessment techniques. However, the demise of Three Mile Island Unit 2 (Reference 1), in 1979, illustrated some of the pitfalls inherent in a diagnostic approach. Since then, all western countries with significant nuclear electricity supply programmes have recognized the benefits of a symptoms oriented approach for operator response to, and actions following, severe plant upsets (References 2 through 10). Most have, in one way or another, implemented symptoms based Emergency Operating Procedures which attempt to measure acceptable plant response by monitoring the general status of the plant. There are two purportedly different approaches being developed and implemented - the State approach (References 4, 8, 9, 10) and the Safety Function approach (References 5, 6, 7).

New Brunswick Electric Power Commission's (NB Power) approach is a pragmatic application of the State approach adopted by Babcock & Wilcox and Electricité de France (EdF). Since its inception in 1981, the NB Power approach has postulated that acceptable fuel cooling, heat removal and containment require the monitoring of and response to a limited set of parameters.

The development of symptoms oriented Emergency Operating Procedures for the Point Lepreau station has followed a complementary two track structure. Both tracks are based on monitoring the thermodynamic state of the primary and secondary system fluids. One track deals with plant upsets where the nature of the cause of the upset is recognized. The other track caters to upset conditions where the event has not been recognized or additional malfunctions, including operator errors, have occurred.

THE "STATE" APPROACH & THE "SAFETY FUNCTION" APPROACH

The "State" approach is founded on the hypothesis that at low powers:

i) adequate fuel cooling and heat transport are dependent on the thermodynamic state of the primary (Heat Transport) circuit fluid and
ii) that the response of the fluid state should dictate all actions.

The State approach is an application of process control first principles. The broader application of the State approach to the processes of fuel heat transfer, heat transport and also boiler heat transfer demands the recognition of the fundamental parameters which describe the acceptable/unacceptable status of these processes. These "Critical Safety Parameters" (Refernce 10) then form the basis of acceptance/corrective action decisions.

Imperfections in fuel cooling and heat removal can lead to either or both high containment pressure or activity and consequently in EOP applications they too are Critical Safety Parameters. The strategic importance of the State approach to EOPs relates to giving the Control Room Operating Crew a direct means of establishing adequacy, unlike the traditional approach involving event diagnosis and prognosis which was indirect. Electricité de France and Babcock & Wilcox (References 3, 4) are generally credited with identifying and developing State based EOPs although, as early as 1981, NB Power had prepared EOPs structured on a plant state monitoring framework - see EVENT SPECIFIC EOPs later.

The Safety Function approach, generally credited to Combustion Engineering and Westinghouse (References 6, 5), is a derivative of the State approach. It categorizes the Critical Safety Parameters according to function, eg. Core Cooling, Subcriticality, Heat Sink, Primary Circuit Integrity, Containment, Inventory etc. Such categorization may be perceived to have some cognitive advantages. These perceived advantages are countered by the recognition that it is the parameters which describe these functions which dictate acceptability or corrective action and the Safety Functions are not independent, eg. at least three of the Safety Functions are functions of the same two parameters - primary pressure and fluid temperature. Nevertheless, the Safety Function approach; like the State approach, demands an overview of the status of fuel cooling, heat removal and radioactivity confinement and it does so via the recognition of Critical Safety Parameters.

The control room implementation of both approaches also shows considerable similarity. Both EdF and Westinghouse applications involve a parallel and independent implementation of State or Safety Function monitoring simultaneously with the application by the Operator of event recognition and response procedures. In principle, there is no overwhelming need for event recognition and response procedures. However, the current view is that, for most events, Event Specific EOPs provide for rapid and optimized response.

The Point Lepreau EOPS are of two types. One type deals with plant upsets where the nature of the cause of the upset is recognized and an Event Specific EOP exists for that cause. The ability to predict anticipated plant response is perceived as a major advantage of Event Specific EOPs since it permits the optimization of corrective actions. The Event Specific EOPs have adopted an integrated State monitoring - event prognoses structure. They call for an integrated response from the Control Room Operator where he is required to address a small set of Critical Safety Parameters, regardless of the event, in addition to addressing the predicted event consequences.

The second type of Emergency Operating Procedure is complementary to the Event Specific EOPs, as shown in Figure 1, in that it caters to upset conditions where,

a) the Critical Safety Parameters are outside defined acceptable values or
b) the Critical Safety Parameters are trending towards their unacceptable limits and
   i) the cause of the event is not recognized or
   ii) the cause is recognized but no Event Specific EOP exists.

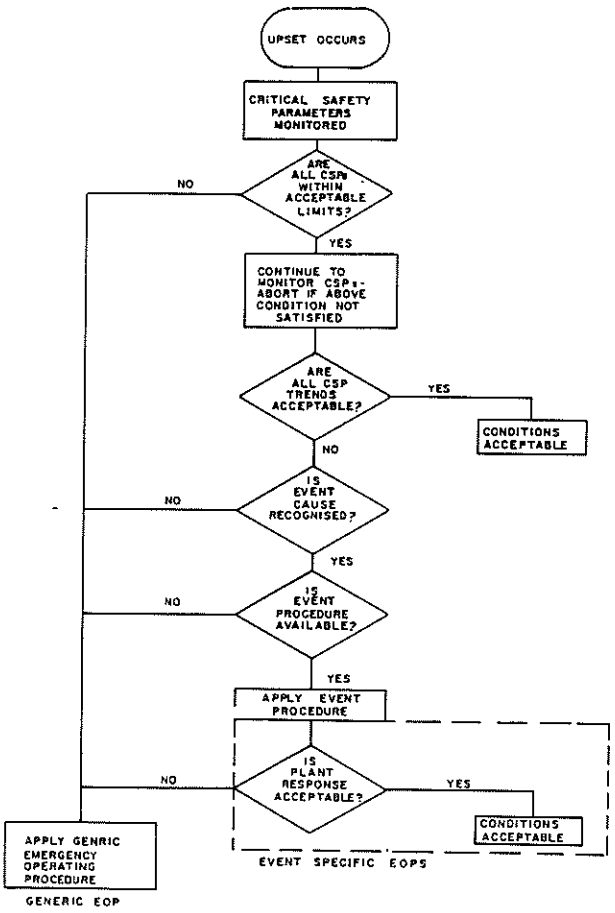

FIG I EMERGENCY OPERATING PROCEDURE APPLICATION

This "Generic" EOP provides a "defence-in-depth" capability to the existing Operating Procedures - the Operating Manuals and the Event Specific EOPs. These existing procdures are not only conceived to provide for operating the plant in a manner which prevents severe upsets but also provide for response when unwanted but anticipated and recognized upsets occur. The generic EOP caters to both unanticipated and anticipated upsets in a manner which does not require cause recognition or fault diagnosis.

EVENT SPECIFIC EOPs

Event Specific EOPs have been prepared for a number of event types including loss of support services such as electrical power, cooling water, instrument air, feedwater and computer control. They have also been prepared for small and large Loss of Coolant upsets and boiler tube failure upsets.

In each of these EOPs the operator is provided with a master plan in logic diagram format. This logic plan, in addition to catering the identified upset, demands the continued monitoring of a set of Critical Safety Parameters which provide for overall plant status acceptance/corrective action. Preparation of each procedure includes the study of a wide range of additional possible complications. These studies have confirmed that additional complications can be addressed via the same set of Critical Safety Parameters. As an example; specific upset conditions initiate opening of the primary (Heat Transport) system overpressure protection valves thus incurring the possibility of failure to close. Such failure is recognizable by primary circuit pressure being below some "normal" value thus obviating the cumbersome and much less reliable diagnoses of valve position status.

All Event Specific EOPs are structured around the response of the plant as measured by:

Reactor Power
Containment Pressure
Containment Activity
Secondary (Boiler) Pressure
Primary (Heat Transport) Pressure
Primary (Pressurizer) Inventory
Secondary (Boiler) Inventory

By adopting standard requirements based on accident analyses and plant trip response measurements, all Event Specific EOPs have a similar structure. Typically, for non LOCA events, the Control Room Operator is required to confirm that either the Reactor Regulating System or Shutdown System One has successfully made the reactor subcritical, that Boiler Pressure is not below 3.6 MPa(g) and falling, that Heat Transport Pressure is not below setpoint (computer controlled) and falling. Satisfying these conditions takes precedence over other actions throughout the use of the Event Specific EOP. The LOCA EOPs are similarly structured except that boiler pressure requirements are different and containment requirements must also be addressed.

The format is therefore an "interrupt-driven-logic" structure where, if any Critical Safety Parameter specified condition is not met, addressing that parameter has precedence. The Critical Safety Parameters are arranged in an interrupt hierarchy which reflects both the interaction of the parameters and their predicted time constants. Typically, Boiler Pressure low and falling has a direct effect on Heat Transport pressure and has priority over it. Boiler levels have much longer time constants re fuel cooling and heat removal than Pressurizer level and therefore have lower priority.

This approach has produced a standardized framework for operator response. Typically, REACTOR POWER is addressed before CONTAINMENT PRESSURE and ACTIVITY which in turn is addressed before SECONDARY PRESSURE, before PRIMARY PRESSURE, before PRIMARY

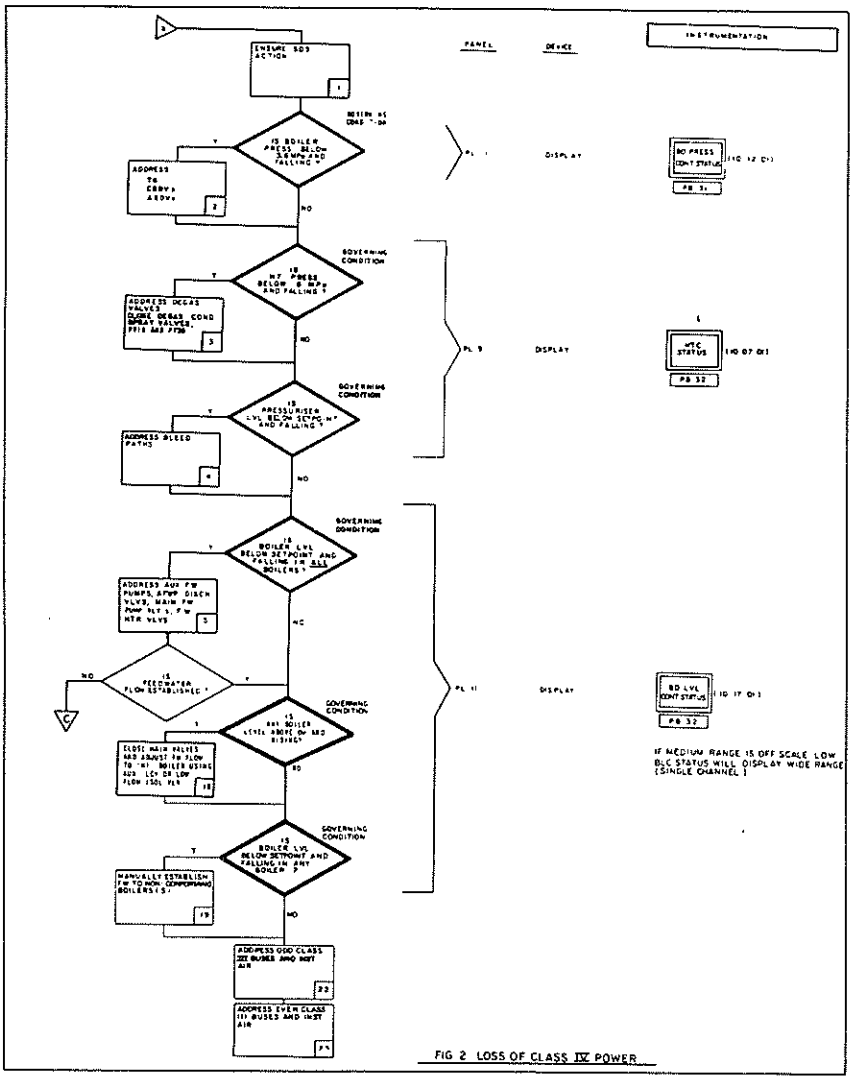

FIG 2 LOSS OF CLASS IV POWER

INVENTORY, before SECONDARY INVENTORY. This "rule" provides for the assurance of acceptable plant states for a wide range of upsets including all classical design basis events. It provides the Control Room Operator with a standard structure for handling upsets, regardless of cause, and has formed the basic structure for Operator training and the Event Specific EOPs prepared for the Point Lepreau Generating Station.

The format of the Event Specific EOPs is illustrated in Figs 2 & 3, the former for a Loss of Class IV Power (Loss of Offsite Power & Turbine Trip) and the latter for Dual Computer Failure.

In both cases Reactor Power is addressed before Boiler Pressure etc. Each of the Critical Safety Parameters is progressively identified as a "GOVERNING CONDITION" which is interpretted by the Control Room Operator as - if at any time the condition is not satisfied it has priority over current activities. In both cases the expected plant response is the vertical path. Horizontal, corrective action, paths imply that additional complications have arisen in the plant response. Each of the Governing Condition diamonds explicitly demands interrogation of the status of a Critical Safety Parameter and, alongside each diamond, the instrumentation to be used is identified in mimic format. The preparation of the EOP requires the selection of explicit instrumentation which a) will directly enable the response to be identified, which b) unless affected by the event is consistent with the Operator's normal activities and which c) provides for redundancy and rationality checks. The comparison of Figs 2 and 3 illustrates the ease with which the operator can address the necessary instrumentation when a computer is available. In the case of Loss of Class IV power three CRT screens are sufficient. When neither computer is available, as during the Dual Computer Failure case, the operator has the added complexity of having to "data process" from hard wired indicators.

Both examples illustrate how overall plant monitoring and the prognosticated response to the specific event can readily be integrated and presented on a single page of uncomplicated logic - for two extreme classical events.

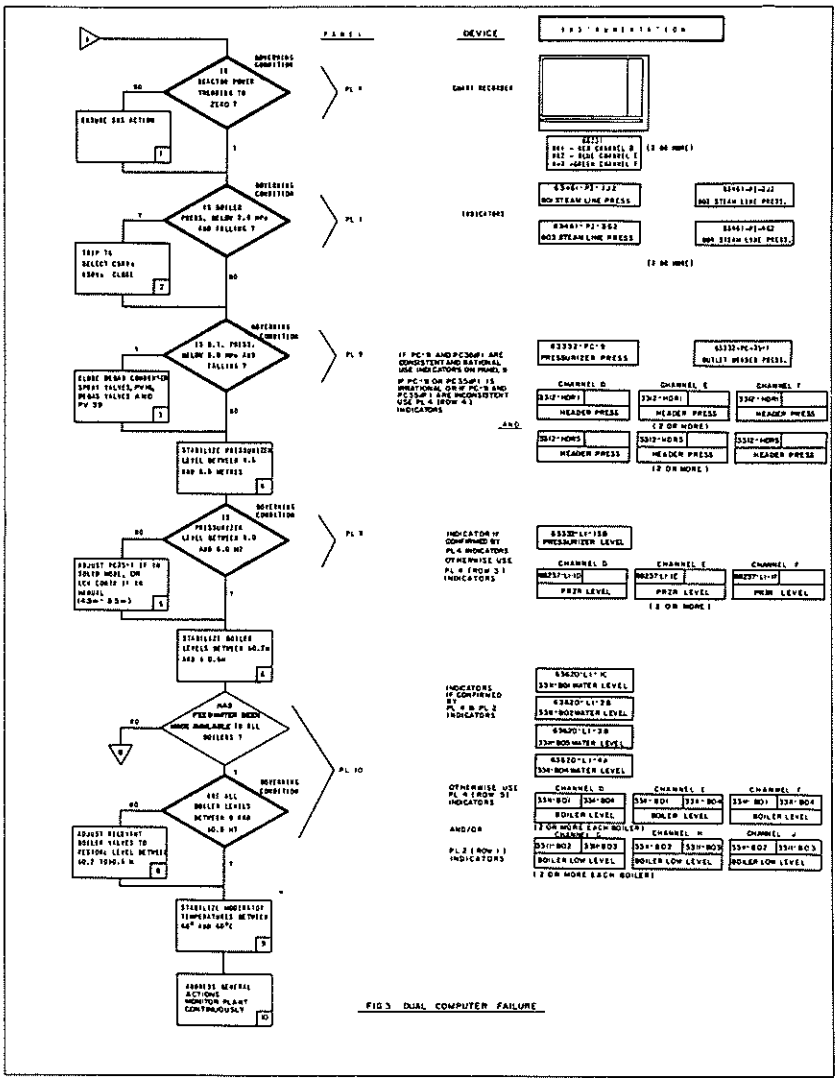

FIG 3 DUAL COMPUTER FAILURE

Operating practices and procedures have almost precluded events where any Event Specific EOP has been implemented. Two specific applications of an Event specific EOP have occurred in five years of operation. Both resulted in subsequent fine tuning of that EOP and both supported the overall concept embodied in the EOP.

GENERIC EOP CRITICAL SAFETY PARAMETERS - BOILER CONFIGURATION

The Generic EOP is structured to handle several distinct heat sink configurations. The present discussion is restricted to the Boiler Configuration without the use of ECC. It deals with satisfactory fuel cooling, heat transport of the reactor energy and heat transfer to the boiler secondary - by monitoring the primary and secondary fluids. It is assumed that no Emergency Core Cooling injection has been demanded. This immediately preconditions subsequent logic and, more interestingly, creates the requirement that the developed rules identify when the indicated thermodynamic state requires ECC initiation. Traditionally, automatic initiation of ECC in CANDU reactors has utilized coincident logic requiring the coincidence of two unlikely indications, such as low primary pressure and high reactor building pressure, where the coincidence has only weak correlations with events other than LOCAs. The fluid thermodynamic state approach provides a complementary solution which, for some conditions, may properly demand the use of ECC when the traditional coincidence requirements do not demand it.

Fig 4 is a schematic of the primary and secondary processes of a CANDU nuclear power plant. Fig 5 is a simplified process schematic identifying the available fluid parameter measurements.

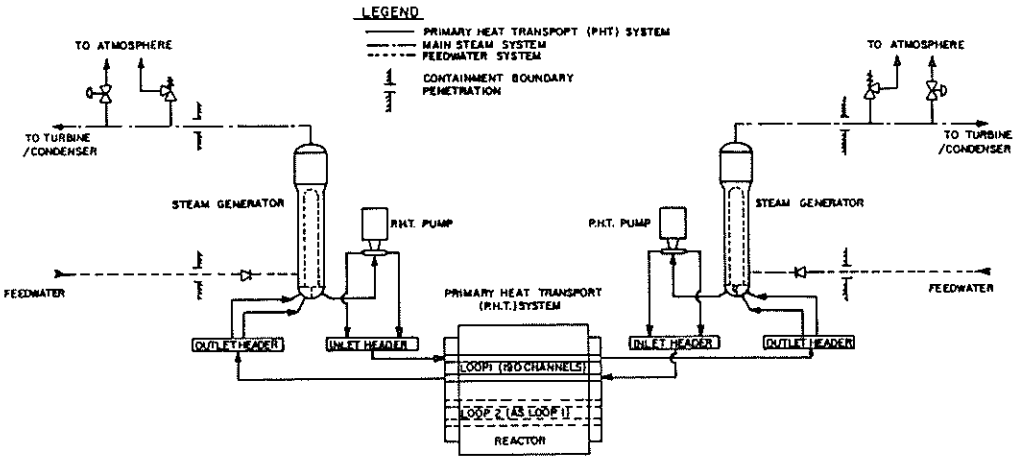

FIG 4 CANDU PRIMARY / SECONDARY SCHEMATIC

Pressure and temperature are measured in both inlet and outlet headers. Channel outlet temperatures are also measured as are flows in specific channels (not shown). Boiler pressure and levels are measured. The thermodynamic state of the fluid in the inlet or outlet headers can be precisely established from the identified meaurements, provided the fluid is single phase ie., if the fluid is subcooled or superheated, its state can be determined. Superheat in any header is a condition where there is, at best, uncertainty with respect to fuel cooling. Any as yet unused provisions which can remove the superheat should be implemented. Typically, ECC initiation, boiler depressurization etc. tactics are appropriate.

Subcooling conditions prevailing in both headers correlate experimentally and analytically with fuel cooling and heat transport adequacy. These conditions are alone insufficient to assure heat transfer to the boilers. Adequate heat transfer to the boilers requires that the Q = U.A.LMTD equation be satisfied. HT fluid state is alone insufficient. To satisfy the requirement for heat transfer surface, the "A" term in the Q equation, requires a minimum boiler level. Satisfying the LMTD term requires that an adequate temperature difference exists between primary and secondary fluids. Direct measurement of secondary temperature is not available but adequate temperature difference can be obtained from inferring secondary temperature as that corresponding to saturation and comparing that with outlet header temperature. The corrective action response to an inadequate temperature difference is to lower boiler pressure or, in the case of no outlet header subcooling - as discussed later - to raise primary pressure. The LMTD requirements can thus be referred to primary and secondary pressure differential requirements. The minimum U in the Q equation arises from natural circulation conditions and in any event the HT pump NPSH requirements are more demanding on subcooling than the heat transfer or transport requirements of the shutdown reactor.

Subcooling conditions prevailing in one header and saturation conditions in the other also correlate experimentally and analytically with fuel cooling and heat transport adequacy but are alone insufficient to assure heat transfer to the boilers. Adequate heat transfer to the boiler secondary requires similar treatment to that already discussed.

Saturation conditions in the inlet header, or for the more conservatively minded - an insufficient inlet header subcooling margin, does not necessarily imply inadequate fuel cooling. It merely implies that if means are available to restore inlet subcooling their use should be implemented. Typical measures are a reduction in boiler pressure or use of ECC inlet header injection. The tactics for differentiating which to use can easily be based on different subcooling setpoints. Typically, if inlet header subcooling is below 25°C and falling, corrective actions should include HT pressure control and boiler depressurization and, if inlet header subcooling is less than 5°C, ECC injection should be used.

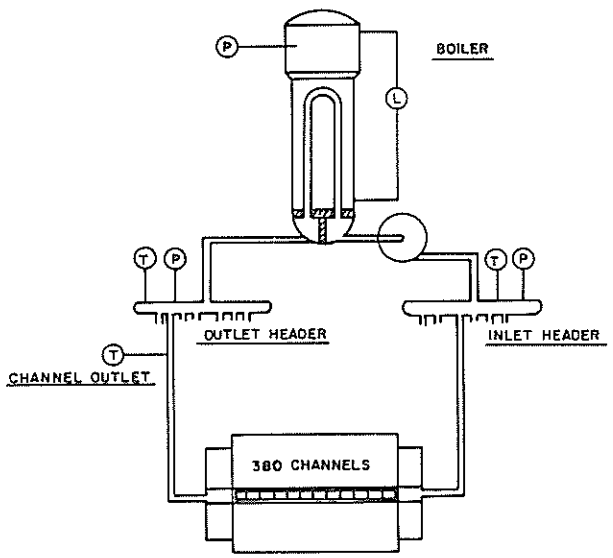

FIG. 5 SIMPLIFIED CANDU SCHEMATIC

The "Generic" Critical Safety Parameters for the boiler configuration therefore reduce to:

Reactor Power (assurance of shutdown)
Inlet Header Temperature
Outlet Header Temperature
Inlet Header Pressure
Outlet Header Pressure
Boiler Level
Boiler Pressure

The justification of using these parameters requires a deeper theoretical treatment than has been described and the validation that these parameters and the resulting logic system is sufficient requires specific case application of a large and varied set of scenarios. The logic structures being used in the development of the Generic EOP for Point Lepreau have adopted the "interrupt-driven-logic" approach used in the Event Specific EOPs. A typical skeleton logic structure for the Boiler (non ECC) configuration is shown on Fig 6.

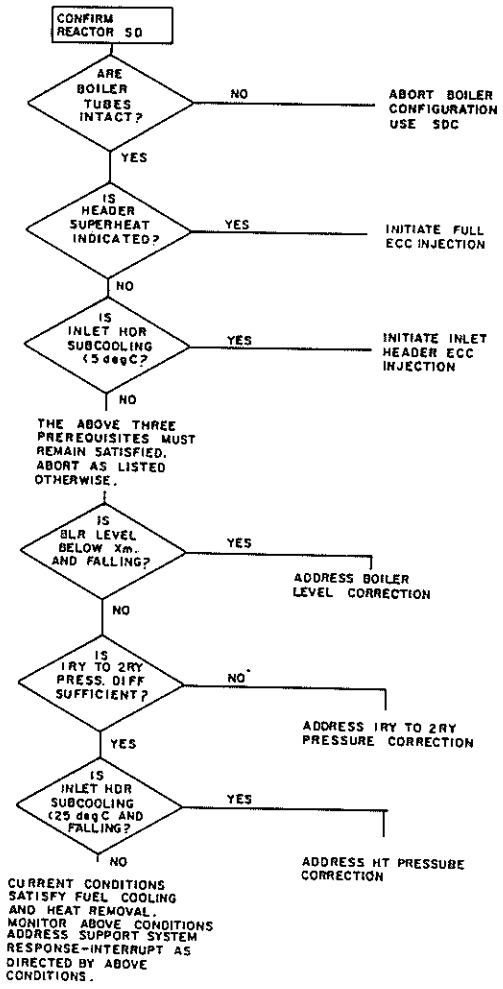

FIG 6 SKELETON LOGIC FOR GENERIC EOP - BOILER CONFIGURATION

Each of the conditions (diamonds) listed in Fig 6 represents an

"INTERRUPT
WHEN
.....,
ELSE CONTINUE"

logic statement in which the WHEN implies a continuous monitoring of the identified CSPs - an activity which lends itself to some automation with or without the use of computers.

The selection of the above set of Critical Safety Parameters does not preclude the use of some of the more traditional parameters such as Pressurizer Level, Heavy Water Storage Tank Level, Class III Bus Voltage etc. Nor does it preclude the use of equipment status information such as ENERGIZED/DE-ENERGIZED, CLOSED/OPEN etc. The use of these "support" parameters is conditional upon the status of the listed Critical Safety Parameters which relate immediately and directly to fuel cooling and heat removal.

CONCLUSION

The defence in depth philosophy associated with the design of nuclear power plants has been incorporated in the operating principles of the Point Lepreau I generating station. Emphasis is placed in three distinct and independent approaches. Operating instructions and procedures are written and applied to minimize the occurrence of severe plant upsets. Procedures for identifying the cause of and required response to severe plant upsets are prepared and included in System Operating Manuals or Event Specific Emergency Operating Procedures. They are applied if the relevant severe plant upset occurs. Thermodynamic State based Emergency Operating Procedures are being developed for severe plant upsets beyond the design bases events. The Event Specific EOPs and the Generic EOP both demand that an overview of the plant response is obtained such that, regardless of the upset, fuel cooling, heat removal and radioactivity confinement are addressed directly. Critical Safety Parameters are identified in each EOP, monitored by the Control Room staff and corrective actions implemented as dictated by these parameters.

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Kingston. The latter is a second-generation reactor operating with slightly enriched uranium fuel. Three others operate at the Saskatchewan Research Council in Saskatoon, AECL Radiochemical Company in Ottawa, and offshore at the University of the West Indies, Jamaica.

The modification can double the core life of the first generation of SLOWPOKE-2 reactors and extend the fuel core lifetime of the most recent reactors from 20 to more than 30 years.

Federal Energy Policy Review Underway (CP)

Representatives of the Canadian energy industry met in June in the City of Calgary at the beginning of a six-month process aimed at developing a new energy strategy for the country.

Federal Energy Minister Marcel Masse opened a two-day conference entitled Energy Options, the first of a series that will be held across Canada.

Masse said he hopes the process will lead to a reorientation of thinking about Canadian energy policy.

"I believe that the work of the next several months, commencing with this conference, will move us towards a greater understanding of energy realities. . . and will enable all of us eventually to plan better," Masse told the gathering.

The group will hold conferences like the Calgary one across the country and will also commission studies on the various energy sectors in Canada. Following a final conference in Montreal in December, the advisory group will come up with recommendations for a new federal energy strategy.

Ontario Emergency Planning Review Group Seeks Input (Solicitor General of Ontario)

In the light of Chernobyl and of other knowledge gained in the last few years, the Government of Ontario has decided that a reappraisal should be made of the present levels of planning.

To carry this out the Solicitor General of Ontario has set up a Provincial Working Group to examine the issue of the upper limit of detailed emergency planning and preparedness to deal with a radioactive release due to a nuclear accident.

In the current Provincial Nuclear Emergency Plan the upper limit dosage for detailed emergency planning is 25 rem at the plant boundary, and detailed planning is in place for a zone of 10 km around nuclear generating stations.

The Working Group invites written submissions from interested persons and parties. These should be sent by August 31, 1987 to:

K. G. McNeill, Chairman,
Provincial Working Group #8,
60 St. George St., Room 308,
Toronto, Ontario. M5S 1A7.

In recommending an upper limit for detailed planning, the following factors should be considered, among others:

- Scientific assessments of the risk of different types of accidents (in terms of estimated probabilities and effects), and the validity of such assessments.
- Risks which cannot be systematically assessed (e.g. those relating to hostile action).
- A safety margin, where not already incorporated, to allow for the uncertainties involved.

For further information, and to obtain copies of the full terms of reference of the Working Group, call (416) 978-5255.

Basic Safety Principles for Reactors Being Formulated (IAEA Newsbriefs)

Basic safety principles for existing and future types of power reactors are being formulated by the IAEA's International Nuclear Safety Advisory Group (INSAG), a panel of experts from Member States that was formed in 1984.

Meeting at the IAEA in May, INSAG reviewed the first draft of a document on the subject, and a final report is envisaged following the group's next meeting in December 1987. Most of INSAG's efforts this year will be devoted to the formulation of basic safety principles, with special attention being given to principles that emerge from post-accident analyses. The work is one element of the Agency's expanded program in nuclear safety and radiological protection in response to the Chernobyl accident.

The planned document is intended to provide guidance to designers, constructors, operators, and regulators of nuclear power plants around the world. INSAG, however, does not regard the principles as a set of requirements to be adopted for regulatory purposes. Rather, they are viewed as fundamental concepts that could be applied to all reactor types and all countries, and they embody targets and conditions for plant safety. Areas covered include siting, design, construction, operation, maintenance, accident management, and emergency preparedness.

INSAG is an advisory body to the IAEA's Director General. It is chaired by A.P. Vuorinen of Finland and includes experts from Brazil, Canada, China, France, Federal Republic of Germany, German Democratic Republic, India, Japan, Republic of Korea, United Kingdom, United States and USSR.

Fish Farm Using Nuclear Heat Opened (Ontario Ministry of Energy)

The Coolwater Farms aquaculture centre in Pickering, Ontario was officially opened in June.

Coolwater Farms, Ltd., located in a decommissioned pollution control plant on Frenchman's Bay, uses warm water from the Pickering Nuclear Generating Station to breed fish year-round. The centre got underway in 1985, following an agreement between the Ministry of Energy and Ontario Hydro to share the cost of the 1-kilometre pipeline which carries water from the generating station to the centre. The Ministry of Natural Resources provided the centre with permits for the acquisition of perch, eels, walleye and whitefish from wild stocks in several areas in the province. Coolwater Farms began the commercial production of rainbow trout in February 1987, and the company is currently working on producing yellow perch and eels for foreign and domestic markets.

EC Proposes Radiation Intervention Levels (Nucleonics Week)

A consensus is growing within the European Community for adoption of radiation limit levels in foodstuffs and drinking water. The Community's Economic & Social Committee (ESC) has just given the stamp of approval to last month's formal proposals by the European Commission to establish uniform permissible levels of radiation in agricultural products across the 12 EC member states. But the ESC also called for a system of guidelines that is "adaptable" as new scientific data become available.

The ESC is one of two consultative bodies, the other being the European Parliament, with whom the EC must confer before voting to pass most proposals into Community law. Its 189-strong membership is drawn from trade, industrial and consumer groups across the EC and is non-political in nature. The ESC called the proposals "justified" from the political, commercial, and public health points of view and said that they "seem likely to achieve a balance by fulfilling the need to protect the health and safety of the public without jeopardizing the production, processing, marketing, and distribution of agricultural products."

The community now awaits opinion on the proposals from the European Parliament, clearing the way for a final debate and vote this fall by the executive council of the member states. The latter have until October 31, when present radiation guidelines are set to expire, to reach a decision.

	Dairy products	Recommended Levels (Bq Kg or Bq L)		
	(including	Other	Drinking	Animal
Isotopes	baby food)	Foodstuffs	Water	Feed Stocks
Iodine, strontium	500	3,000	400	—
Plutonium, etc.	20	80	10	—
Cesium, etc.	1,000	1,250	800	2,500

Yellow Book Lowers Nuclear Capacity Projections by 40-50% (OECD NEA)

The OECD Nuclear Energy Agency (NEA) announced in June the publication, jointly with the International Atomic Energy Agency (IAEA) of the third edition of its report "Nuclear Energy and its Fuel Cycle" (known as the "Yellow Book").

Weighing the prospects to the year 2025, the report notes that nuclear capacity likely to be installed in the short term (1995) will be largely determined by past decisions, although it can still be affected by construction or licensing delays, and changes in national or utility policies. Between 1995 and 2000 a modest expansion of nuclear capacity is to be expected in OECD countries, while beyond 2000, the picture is more uncertain, with installed nuclear

capacity lying anywhere within a wide range. However, current projections for 2025 are some 40 to 50 per cent lower than those made in the last (1982) edition of the report, due to the economic recession, reduced ordering rates and lower growth rates.

Though these projections were finalised before the Chernobyl accident in 1986, the report notes that despite any influence this event might have on national nuclear power programs, the overall outcome would probably not be significantly different from that envisaged in the low growth scenario for the next 40 years.

For the *short term*, that is 1985 to 1995, average nuclear power growth rates over the decade are projected to be respectively 4.4 per cent a year for OECD; 6.1 per cent for the developing World Outside Centrally Planned Economy Countries, and 8.9 per cent a year for Centrally Planned Economy Countries. But the report notes that if nuclear energy is to meet the goals set by energy planners in OECD countries for the rest of the century, all projects currently in the pipeline must be completed, and approximately 50 GWe of additional nuclear capacity must be ordered and construction begun between 1986 and 1995. The ability to handle this level of orders appears to be within the current capacity of the nuclear industry. On the other hand, as electricity growth rates and nuclear program expectations have declined over the last decade, nuclear reactor vendors, equipment and service suppliers, and construction companies have taken measures to reduce surplus capacity and skilled manpower. Thus, questions have been raised as to whether a prolonged absence of orders in the short term could have a critical effect on the industry's ability to respond to future projected increases in nuclear capacity additions. On the other hand, this period can be viewed as one in which the current over-capacity in all supply sectors of the nuclear fuel cycle will be progressively eliminated.

In the *longer term,* i.e. the period 1995 to 2025, there is a larger uncertainty concerning the overall level of energy, electricity, and nuclear power demand, the mix of nuclear power technologies to supply the nuclear contribution, and the level of resources and services required. Since the next century may well be characterized by dwindling oil and gas resources combined with an improvement in the living conditions in less-developed countries, the pressure to switch to more abundant and cheaper sources of supply such as nuclear power and coal may be large. Because of these uncertainties, a scenario approach was used to project electricity and nuclear energy growth, using also varying reactor deployment strategies. In summary, over the long term, fuel supply requirements may vary considerably depending upon developments in factors external to the nuclear industry. This suggests that a flexible strategy should be advantageous to both producers and consumers and, therefore, that efforts should continue to support uranium exploration and development of advanced enrichment technologies as well as advanced fuel cycle and reactor options which reduce requirements.

Letters to the Editor

How Good Are the Data?

The thoughtful editorial, "How Good are the Data?" (*CNS Bulletin,* May/June, 1987) raises some very interesting starting points. Regardless of safety studies, it is a fact that there have been two serious commercial reactor accidents in about 4000 reactor years. It is certainly a point worth noting that the two machines involved were quite different in design, and were operated in quite different political and cultural environments. However, one must be a little careful in seeking to disqualify either event as a data point on such specific grounds since this, carried to its logical conclusion, would tend to limit a safety study to a specific reactor type at a specific location in the charge of a blue-eyed station manager called Fred.

A useful question to pose might be: "Do the TMI and Chernobyl reactor accidents have any features in common?" The answer is clearly an affirmative one. Both reactor accidents were attributable to failures in "institutional" nuclear safety, as distinct from engineered nuclear safety. In the case of Three Mile Island not only was there a general institutional failure to provide operators with appropriate training, but there was the highly specific failure to transmit successfully through the nuclear energy community important details about an event at the Davis Besse plant – a similar machine to TMI Unit 2. Had the operators at Three Mile Island been aware of the implications of the Davis Besse incident it is highly probable that they would have responded appropriately to the situation and TMI Unit 2 would be in-service at this time.

At Chernobyl the institutional structure was deficient in that it permitted an important test to be conducted on the reactor under the direction of a person who was not part of the station complement and, moreover, who was "not a specialist in reactor plants." Much ink has been spread on the various "design deficiencies" of the RBMK reactor, but the design features *did not cause the accident* – the reactor was quite deliberately operated in a forbidden regime, operating principles were violated and trips were disabled. By analogy one might note that should an airline pilot attempt an Immelmann turn in a Boeing-747 the aeroplane will probably break and crash. Airliners are not typically designed to accomplish such manoeuvres and institutional measures – specifically appropriate air traffic control arrangements – should be taken to preclude the necessity for violent aerobatics.

In the area of nuclear accidents attributable to institutional failure one can find at least one other important data point, the SL-1 accident of January 1961. It is probably true to say that "everybody knows" the accident was actually caused by the sudden manual withdrawal of a single control rod by an operator for some unexplained reason. What is perhaps less generally appreciated is that the reactor should probably not have been allowed to operate after September 1960, when significant mechanical damage to the core was discovered, and certainly no operation after December of that year should have been considered in light of about 40 cases of control rod jamming over the last seven weeks or so of operation. Indeed these problems had been recognized and a new core of different design was to be procured. Yet the reactor was allowed to continue operation. The institutional problems which brought about this situation have been well identified, by both C.A. Nelson (in his final report on the SL-1 accident) and T.J. Thompson (in his chapter "Accidents and Destructive Tests" in *The Technology of Nuclear Reactor Safety*).

Of course institutional failures are not confined to the nuclear safety business as last year's explosion of the *Challenger* shows. Of very much higher human cost was the tragic accident to the cross-channel ferry *Herald of Free Enterprise* earlier this year which has been attributed to "human error" by P&O Chairman Sir Jeffrey Stirling. The term "human error" is correct enough, but must be interpreted widely enough to include those errors which were made before the vessel slid down the ways, and by people other than the crew. As a recent editorial in *New Scientist* pointed out, "Both companies (P&O and Townsend Thoresen) are well aware that a few centimetres of water on the open vehicle deck of a roll-on, roll-off ferry is enough to capsize a ferry. Naval architects have warned them about the problem often enough, and Townsend Thoresen lost another ferry, the *European Gateway*, in 1982 because of such a sheet of water." The editorial goes on to note that this vessel, with state of the art controls and sensors to achieve rapid turn-around, was yet not provided with even the most rudimentary means of confirming from the bridge that the fore and aft sea doors were properly closed.

The ship laboured under a design feature which made it particularly vulnerable to certain "operator errors" on the part of the crew, a design deficiency which greatly increased the probability of an error remaining undetected and an institutional/economic pressure (the requirement for rapid turn-around) which significantly increased the probability of an error in the first place. As *New Scientist* so trenchantly noted, "some of the human beings who make the errors sit on the boards of the ferry companies." Institutional failure is human error which typically occurs at locations remote in time, place and corporate hierarchy from the flight deck, the bridge or the control room. It is one of several challenges to safety – in the air, at sea or in nuclear power stations. The fact that it may be less easy to deal with than simple "human error" at a control panel or "design error" in the drawing office does not mean that we should ignore it. Indeed the fact that we can identify it is perhaps the first step towards coping with it.

David Mosey

CNS Division Update

13th Annual Reactor Simulation Symposium – Conference Report

Sponsored by the Nuclear Science and Engineering Division of the CNS, and hosted by CRNL, the 13th Annual Reactor Simulation Symposium was held at CRNL, April 27 and 28. 78 participants were in attendance and 35 papers were presented. Norm Spinks was Chairman.

The conference covered all aspects of nuclear power plant modelling and simulation. The 35 papers were grouped into 8 sessions: 3 on thermalhydraulics, 2 on reactor physics and 1 each on plant simulation, numerical methods and fuel channels. Sessions were scheduled in series rather than in parallel as in recent years. This led to short, snappy presentations which were well received.

Participants were welcomed by Dr. Ralph Green, Vice President of Reactor Development at AECL, who mentioned his involvement in organizing the symposium in its early years. At the conference banquet, Dr. Gerry Lynch, Manager of the Local Energy Systems Unit at AECL, stimulated much interest and discussion with his address on the prospects for small nuclear heating reactors.

In summary, this annual symposium continues to be successful in providing a forum for stimulating discussion and exchange of views amongst engineers and scientists in the Canadian nuclear industry.

N.J. Spinks

Interested in Contributing to the CNS Bulletin?

To submit original articles, letters, FYI items, reviews, calls for papers, etc., contact one of the following:

- J. Nathwani, Editor, *CNS Bulletin,* c/o Ontario Hydro, 700 University Avenue, Toronto, Ontario, M5G 1X6.
- The *CNS Bulletin,* c/o the CNS office.
- Your branch or division representative.

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September/October	September 1
November/December	November 1

Intéressés à contribuer au Bulletin SNC?

Pour soumettre des articles originaux, des lettres, des nouvelles, des revues, des appels aux communications, etc., veuillez bien entrer en contact avec l'une des personnes suivantes:

- J. Nathwani, Rédacteur, *Bulletin SNC,* a/s Ontario Hydro, 700 University Avenue, Toronto, Ontario, M5G 1X6.
- Le *Bulletin SNC,* a/s Bureau de la SNC.
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septembre/octobre	le 1 septembre
novembre/décembre	le 1 novembre

CNS Branch Programs

Central Lake Ontario Branch News

On June 24, 1987 Mr. Ralph Hart addressed a group of about 25 people at the Darlington Information Centre about the unique design features of the AECL's CANDU 300MW power station design. Mr. Hart is the technical director at Sheridan Park in charge of the CANDU 300 project. Entitled "CANDU 300 – Faster Construction, Easier Maintenance, Better Operation and Longer Life" his talk generated a lot of interest among members. As was noted in the subsequent question period, the CANDU 300 is the first of its kind to have a comprehensive maintenance design review performed on it prior to the completion of the detailed design phase. A discussion of the present marketing plans and sales prospects was also included.

D.F. Meraw

Toronto Branch News:

AMPS – A Special Purpose Nuclear Electric Plant

On May 26, the Toronto Branch had as their guest speaker Dr. John Hewitt from ECS-Power System Inc. At this well-attended presentation Dr. Hewitt described in detail the Autonomous Marine Power Source (AMPS) design. Originally conceived for mobile small submarine applications, the AMPS design draws on established low-temperature reactor and heat engine technology.

The low temperature reactor will consist of 91 fuel channels arranged in a hexagonal lattice. The fuel used will be uranium zirconium hydride (20% enrichment) enclosed in a stainless steel clad. Dr. Hewitt stated 3 reasons for using this type of fuel:

- There has been wide experience with this fuel in reactors that are similar in design to the AMPS reactor.
- Hydrogen is added to create a negative power co-efficient of reactivity.
- This fuel has good fission product retention at high temperatures.

It is expected that the fuel life will be 1000 full power days. The reactor core will be shielded with H_2O to maintain a small core size and the reactor output should be approximately 100 kWe.

On the thermalhydraulics side, there will be an active and passive cooling system and the heat engine technology will incorporate the principles of the Rankine Cycle. Currently, ECS-Power System Inc. is expecting final commissioning of their design within the next two years.

Dr. Hewitt's seminar was well received as several questions followed his presentation. We wish Dr. Hewitt and his associates continued success in their pursuits to produce a safe and reliable nuclear power source for sub-sea vehicles.

G.J. Sullivan

Reactor Accident Review

Two reactor accidents were the subject of a review carried out recently by David Mosey and on May 4, he presented a summary of his work at a meeting of the CNS Toronto Branch attended by approximately 40 people.

As a starting point, Mosey noted that old reactor accidents are more than just footnotes in the history of power reactor development: they are significant landmarks in the "cultural heritage" of reactor safety, and can yield useful reminders and possibly novel insights if they are examined afresh and in detail. In his presentation, Mosey reviewed the design of the NRX and SL-1 reactors and walked his audience through the sequences of events associated with the accidents that occurred at these installations in 1952 and 1961 respectively.

His main themes were two. The first was that accidents in these early research reactors offer a clear view of the fundamental principles of reactor safety. Since the design and operation of these systems were uncluttered with later accretions in the form of sophisticated safety and operational systems, the reactors themselves and the accidents they underwent offer an equally uncluttered view of the nature of the hazards to be guarded against. Therefore,

Mosey noted, a fresh look at the NRX accident points out clearly the need to be able to guarantee shutdown capability under a range of possible operating conditions, and indicates equally clearly some of the requirements that a shutdown system must be able to meet.
The second theme dealt with the "institutional" factor in reactor safety, including design, operation and the apparently more remote functions of management, training and so forth. Mosey used the SL-1 accident in particular to demonstrate the existence and importance of these institutional factors, indicating that they overlap such specific elements as operator response, review procedures, and the assignment of ultimate responsibility for various phases of a project. He cited examples from the aircraft industry to illustrate these two themes and suggested that a clear formulation and resolution of institutional questions is as important to reactor safety as is the treatment of technical issues.

Keith Weaver

Ottawa Branch News:

New Executive

The officers of the Ottawa Branch for the 1987/88 term have been elected:
Chairman: Joseph Howieson
Secretary: Terry J. Jamieson
Treasurer: John D. Stewart
Councillors: Robert L. Clarke
Daniel J. Gorman
Andrew J. Stirling
A. David B. Woods
(**Past Chairman:** John S. Hewitt)
The outgoing executive was also pleased to announce that a thirty percent increase in branch membership was realized over the past year.

Terry Jamieson

Ottawa Branch News

The 1986/1987 seminar series concluded on May 28 with a presentation by Dr. John Hewitt of ECS-Power Systems on the Autonomous Marine Power Source (AMPS).
The presentation, which was also made earlier in the week to the Toronto Branch, outlined: the history of the first intended application of the AMPS; the power source design requirements; and the design and development program, including the nuclear prototype, the full-scale thermalhydraulic and the organic Rankine cycle tests, to be undertaken in 1988.
Many thanks to all those who contributed to the success of this year's seminar series. The branch members are looking forward to an equally exciting program next year.

Terry Jamieson

Book Review

The Civilized Engineer, by Samuel Florman, St. Martin's Press (A Thomas Dunn book), New York, 1987.

Everyone can recall instances of those magical times that combine good company and good conversation, when discussion ranges widely in subject and in time, from ancient history to modern cuisine, from garden weeds to the Cold War, from philosophers to dirty jokes. Perhaps fewer people are in a position to recall similar experiences in which the subject at hand is some technical topic, but in which every turning in the logic, every attempt to make a new result comprehensible, every blackboard scribble, could conceal or inspire some illuminating quote or allusion, or could give rise to some reference to a field completely outside that being considered. Such deviations from the main discussion can run the gamut from revealing new insights to being capriciously, self-indulgently off topic. The very best of these priceless side trips fall into place with a well-oiled snick and reveal the hand of a craftsman at work.
I approached "The Civilized Engineer" in the hope that it would be just such a well-crafted package incorporating both the commonplace and the cosmic. What I got wasn't quite what I expected.
The engineer that Samuel Florman sees at present is a hard-working, competent individual who enjoys his or her work but whose vision tends to be dominated too much by the monetary rewards, the prospects for advancement, or the nitty-gritty of the technical problems before them. Today's engineer is not sufficiently introspective. The author's view of the problem and his proposals for at least a partial solution are presented in the book's twenty-three chapters. Each chapter is is the form of an essay, and most of them have appeared previously in various magazines and journals. They are collected together here and butt-welded to form a free-standing structure.
The "problem" is presented in almost absolute terms, as though it is an affliction which befalls engineers everywhere. In fact, the book is almost exclusively (North) American in outlook and either fails to signal this restriction early on, or else assumes that engineers are the same everywhere. (My experience is that they are not, that the "problem" described in this book is not nearly as pronounced among engineers from older cultures.) The solution is seen as being a much more varied and imaginative exposure of engineers to the humanities, designed to fan rather than quench their interest. This part of the discussion is hard to dispute, especially if one has endured the soporific drone of those "required" literature classes, whose apparent purpose was to inter forever any incipient attraction to the arts on the part of engineering students.
In setting out the background and describing the perceived problem, the author spends rather too much time (for my taste) reviewing questions of ethics, good practice, and the necessary and desirable process of formalizing these in codes and standards. Some of the chapters suffer in places from a "heart-on-the-sleeve" approach, and in more than one instance, inflammatory metaphors threaten to seize control of the piece (e.g., "The flame of freedom, once ignited, is almost impossible to extinguish").
However, it was the reasons given for applying the proposed solution, or at least the way in which these reasons were presented, which were most disappointing. At one point, the author states:
"The nation needs engineers who are able to communicate, who are prepared for leadership roles, who are sensitive to the worthy objectives of our civilization and to the place of technology in it, and whose creative imaginations are nourished from the richest possible sources – spiritual, intellectual, and artistic. Furthermore, engineers as a group need to preserve their professional esteem – and the esteem of the greater community – by guarding against an insensitive mechanical approach to the work they do. And finally, engineers deserve the chance to enrich their lives with art, literature, history – the best our civilization has to offer."
Surely the emphasis is all wrong here. It seems as though the proposed program of liberalizing the outlook of engineers should be undertaken mainly because it would be in the national interests of the United States, and only secondarily because it would produce fuller, more complete individuals. Just such a jarring, utilitarian note was also struck earlier in the introduction, where, in the course of setting the stage, the author suddenly blurts out:
"Americans have decided that they *will not* be buried under the sands of time."
Despite all this, the book contains many interesting insights. In particular, the issues covered in the final six chapters make these chapters well worth reading. Because of its outlook, however, it can be irrelevant and exasperating at times for non-American readers. If a wider view of the topic had been taken, and more art applied to the same matter, "The Civilized Engineer" could have been an outstanding work.

Keith Weaver

Conference Reports

International Containment Conference Report

An international Conference on Nuclear Containment, sponsored by the British Institution of Nuclear Engineers and the European

Nuclear Society, took place April 6-8 in Cambridge, U.K. The papers and discussion dealt with a number of important issues in containment, including licensing issues at Sizewell B, hydrogen combustion in containment and aerosol modelling.

The high profile issues at the meeting included the question of venting PWR containments following low probability events which lead to high containment pressures, the continuing international work on pressure testing of scale models of containment to failure, and on code predictions of the failure modes of actual containments.

Filtered venting is an outstanding issue at Sizewell B. Several European countries, notably Sweden and Finland, have committed themselves to back fitting their plants with such venting systems. Views are mixed in Britain and the Nuclear Installations Inspectorate (NII) has refused to commit itself on the need for venting. Views are also mixed in the U.S. and this topic received a good deal of discussion.

Response of containments beyond their design pressure is the second outstanding licensing issue at Sizewell B and the CEGB has agreed with the NII to conduct overpressure tests on a scaled Sizewell B containment model. The model for these tests should be ready in about 12 months. Code predictions for the Sandia 1/16th scale containment test (the test itself was carried out during May) were presented and some aspects of the University of Alberta containment tests, sponsored by AECL, were noted during the discussion.

Whiteshell's work on hydrogen combustion was presented in two papers and some calculations by the UKAEA on containment response, including hydrogen burn calculations, were also presented. The UKAEA calculations were of interest because they formed part of the Sizewell B safety case.

Application of containment aerosol models was also presented by a British group.

Overall, the meeting generated lively debate on containment concepts. However, broad agreement was apparent on the priority issues for containment design and analysis. A great deal of progress on both experimental and analytical fronts is expected in the next year or two.

Jerry Hopwood

CEGB Workshop

"Chemical Reactivity of Oxide Fuel and Fission Product Release" Report

This CEGB Workshop, co-sponsored by the British Nuclear Energy Society and the Canadian Nuclear Society, April 7-9, 1987 at Berkeley (UK) was the latest of the annual workshops on dry storage, which includes the 1984 Ontario Hydro Workshop on Irradiated Fuel Storage. It was attended by about 50 experts from the UK, France, Germany, Holland, US (ORNL, LLL, BNL and PNL) and Canada. Three Canadian papers were presented by AECL and Ontario Hydro staff and the session "Oxidation of UO_2 in air and fission product release" was chaired by C.R. Frost (Ontario Hydro).

Many countries, like Canada, have irradiated UO_2 fuel dry storage programs. Thus, the effect on UO_2 oxidation of temperature, UO_2 physical properties, fuel type (LWR, AGR, LMFBR and CANDU) and manufacturing route, oxygen partial pressure and plutonium content described in various papers, will assist in the design of interim irradiated fuel dry storage facilities.

There is currently much international focus on postulated low probability in-reactor accidents. The data reported on the release of fission products (I, Cs, Ru, Te, Rb, Sb and Mo) and/or U_3O_8 particulates from irradiated UO_2 fuels at temperatures up to 2000° C in air and steam-helium-hydrogen atmospheres, and the effect of UO_2 reaction with molten Zircaloy fuel cladding on the releases, may facilitate more precise assessment of the radiological consequences of such accidents. The workshop proceedings, including an account of the discussion periods, will be issued by the CEGB within 4 months.

Colin Frost

Conferences & Meetings

International Meeting on Nuclear Power Plant Operation

Sponsored by ANS, Canadian Nuclear Society, ENS and Atomic Energy Society of Japan, to be held **Aug. 30-Sept. 3, 1987** in Chicago, Illinois. For information contact: **Norman Wandke, Commonwealth Edison Co., P.O. Box 767, Chicago, IL 60690,** or Ken Talbot, (416) 839-1151.

International Topical Conference on Probabilistic Safety Assessment and Risk Management

Sponsored by SNS, ENS, ANS, Canadian Nuclear Society et al., to be held **Aug. 30-Sept. 4, 1987** in Zurich, Switzerland. For information contact: **PSA '87, c/o ENS, P.O. Box 2613, CH-3001, Berne, Switzerland,** or F. King, (416) 592-7597.

Technical Committee Meeting on Uranium Resources and Geology of North America

Sponsored by IAEA, to be held **Aug. 31-Sept. 4, 1987** in Saskatoon, Saskatchewan. For information contact: **IAEA, P.O. Box 100, A-1400, Vienna, Austria.**

Tritium Safe Handling Course

Sponsored by Canadian Fusion Fuels Technology Project, to be held **September 21-25, 1987** in Toronto and Chalk River, Ontario. For information contact: **Course Co-ordinator, CFFTP, 2700 Lakeshore Rd. W., Mississauga, Ontario, L5J 1K3,** (416) 823-0102.

3rd McMaster University Symposium on Nuclear Science and Engineering

Sponsored by McMaster University and Canadian Nuclear Society, to be held **Sept. 30-Oct. 1, 1987,** in Hamilton, Ontario. For information contact: **Dr. J.-S. Chang, Dept. of Engineering Physics, McMaster University, Hamilton, Ontario, L8S 4M1,** (416) 525-9140, ext. 4924.

Second Workshop on Advanced Topics in CANDU Reactor Thermalhydraulics

Sponsored by McMaster University, to be held **Oct. 1-2, 1987** in Hamilton, Ontario. For information contact: **Dr. J.-S. Chang, Dept. of Engineering Physics, McMaster University, Hamilton, Ontario, L8S 4M1,** (416) 525-9140, ext. 4924.

Uranium Mine Radiation Safety Course

To be held **October 19-23, 1987,** in Elliot Lake, Ontario. For information contact: **Canadian Institute for Radiation Safety (CAIRS), 595 Bay St., Suite 1050, Toronto, Ontario, M5G 2C2,** (416) 596-1617.

Symposium on the Transportation of Radioactive Materials

Sponsored by the Canadian Nuclear Association, to be held **October 29-30, 1987** in Toronto, Ontario. For information contact: **Canadian Nuclear Association, 111 Elizabeth St., 11th Floor, Toronto, Ontario, M5G 1P7,** (416) 977-6152.

International Conference on CANDU Maintenance

Sponsored by Canadian Nuclear Society and Canadian Nuclear Association, to be held **November 22-24, 1987** in Toronto, Ontario. For information contact: **D.F. Meraw, Darlington N.G.S., P.O. Box 4000, Bowmanville, Ontario, L1C 3Z8,** (416) 623-6606, ext. 4218.

1987 International Waste Management Conference

Sponsored by ASME and IAEA, cosponsored by ANS, Canadian Nuclear Society et al., to be held **Nov. 30-Dec. 5, 1987** in Kowloon, Hong Kong. For information contact: **L.C. Oyen, Sargent & Lundy, 55 E. Monroe St., Chicago, Illinois 60603,** or Tom Carter, (416) 592-6024.

Safety of Next Generation Power Reactors

Sponsored by ANS; cosponsored by U.S. DOE, Canadian Nuclear Society et al., to be held **May 1-5, 1988** in Seattle, Washington. For information contact: **Alan E. Waltar, Westinghouse Hanford Co., P.O. Box 1970, Richland, Wash. 99352,** (509) 376-5250.

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

Sponsored by Canadian Nuclear Society, cosponsored by American Nuclear Society, to be held **May 1-6, 1988** in Toronto, Ontario. For information contact: **C.D. Burnham, CFFTP, 2700 Lakeshore Rd. W., Mississauga, Ontario, L5J 1K3,** (416) 823-0205.

International Symposium on the Feedback of Operational Safety Experience from Nuclear Power Plants

Sponsored by IAEA and OECD NEA, to be held **May 16-20, 1988** in Paris, France. For information contact: **International Atomic Energy Agency, P.O. Box 100, A-1400 Vienna, Austria.**

28th Annual International Conference of the CNA and 9th Annual Conference of the CNS

To be held **June 12-15, 1988** in Winnipeg, Manitoba. For information contact CNS office, (416) 977-6152.

Symposium on Uranium and Electricity – The Complete Nuclear Fuel Cycle

Sponsored by Canadian Nuclear Society, to be held **September 18-20, 1988** in Saskatoon, Saskatchewan. For information contact CNS office, (416) 977-6152.

International Conference on Thermal Reactor Safety

Sponsored by SFEN, cosponsored by Canadian Nuclear Society et al., to be held **October 2-7, 1988** in Avignon, France. For information contact: **F. Cogne, Société Française d'Énergie Nucléaire (SFEN), 48, rue de la Procession, F-75724 Paris, CEDEX 15, France.**

The Unfashionable Side

The Epistemology Caper

As many of you know, I am a dab hand at safety analysis, even though I have little opportunity to do much these days. The demands of speaking engagements, serving as national chairman of The Alewife Club, advising the Canadian Nuclear Society on how to stem the flood of applications for memberships, and fixing the neighbour's toaster, leave precious little time for anything else.

Occasionally, however, the call to duty is so great that I feel compelled to drop everything. My work in safety analysis has been described in such flattering terms as "phantasmagorical" and "runic" but I feel that it is not beyond what any competent nuclear engineer could accomplish. For example, anyone devious enough to claim that they understand the Siting Guide could have come up with my solution to the recent public acceptance problems of the heavy water plants: locate egg storage depots next to them and when the complaints about odours begin each can blame the other until the unrest dissipates itself. There is nothing but a modicum of creative common sense in all this, since safety analysis is really little more than a highly structured application of the straw man technique.

Such was my confidence as I approached my most recent safety analysis assignment. On the face of it, the job was a fairly routine one. And since I had a full three weeks to analyse and document, there seemed to be time to find the elegant solution. Setting aside all the standard codes and rules, I returned to first principles. At the end of five days, I had become quite concerned because whenever I started from the absolute fundamentals, there was no way that I could demonstrate conclusively, no matter what reasonable assumptions I cared to make, that radioiodine exists at all.

A friend was kind enough to read the first draft of my documentation, paltry as it was. He corrected a grammatical error on page 874 but had no other comments, aside from noting that it would be the first safety report in his recollection that included references to Russell, Whitehead, Popper, Wittgenstein and Gödel. He also admitted that he didn't understand anything in the section entitled "Metaphysical Underpinnings of the Source Term" and that an outside opinion was called for. "We should take it to Berkeley Mill," he concluded.

At this I was delighted since I always enjoy winkling out new hostelries.

"No, you twit! I mean Prof. Berk Mill at Aphasia University." Of course, I recognized immediately that he meant that strange and unconventional genius whose research interests included the intoxicant properties of the luminiferous aether and the moral dimensions of electron-positron annihilation.

Berk, as I learned to call him, or The Berk, as I heard others mutter (I never did understand that one), was completely dishevelled and smelled of oranges. But he welcomed with alacrity both me and my problem; my documentation he waved aside with impatient good humour, asking me instead to outline the difficulty in my own words. I explained the situation, concluding, "So it seems that there is some logical contradiction somewhere, perhaps a problem with axioms or an internal inconsistency in determinism that hasn't been encountered before."

He chuckled paternally and pulled me back from this philosophical brink. "Hardly surprising that you're confused," he said through his rumbling laugh. "First thing to do is tighten up your terminology. Determinism is far too general a designation. We have made *some* modest advances since Democritus' time." With that he launched into a discussion of the problem of knowledge and concluded twenty minutes later by emphasizing that it is impossible to overcome, at a fundamental level, the legitimate arguments of a dyed-in-the-wool Sceptic.

"So you see," he ended, "you must come to terms with where you stand between the Naive Realists and the Scientific School."

The light dawned. "Ah! Well, I enjoy El Greco, Norman Mailer and Bob Seger, so presumably I'm fairly middle of the road "

His face clouded irritably but I could understand readily enough. Many is the time that I too have had my train of thought broken by remembering that I had left the shopping list on top of the refrigerator. It was comforting to see that others made these annoying slips as well.

He composed himself and approached the problem with renewed briskness. "Most engineers are naive realists without knowing it," he explained, "and perhaps that's all for the best. The Sceptics are sure that all engineers are wrong, but they can't explain, if that is so, why all those bridges fail to fall down year after year. You seem to have drifted off the track and become a reductionist somehow. Do you feel that you are a reductionist?"

I shrugged, not unlike Atlas I hoped. "I don't think so, therefore I suppose I'm not."

He was beginning to lose interest in the whole affair. "If you can't prove to yourself that the very tools of your trade exist, perhaps you should try your hand at something different."

"Oh, no", I corrected him quickly. "It's only one thing whose existence I can't demonstrate. Everything else is fine."

He became very still and was suddenly intensely interested. "Only one thing?" he asked softly. "What thing is that?"

After demonstrating a nice control of caesura, I dropped the word gently into the space between us. "Iodine."

His brows knitted ferociously but then suddenly his face cleared and he began to smile. "You've come to the right place then, because I can prove to you that it does exist."

He opened his desk drawer, took out a small bottle and placed it on his blotter. "Iodine," he intoned, with smug professorial finality.

"But that doesn't prove that it exists," I objected. "What do you mean it doesn't prove that it exists?" he barked heatedly. "Dammit man, you can *see* that it exists!"

Less than two hours after he threw me out, I proved that whole body doses don't exist either and the party was still going strong a week later.

George Bauer