CANADIAN NUCLEAR SOCIETY

Bulletin

DE LA SOCIÉTÉ NUCLÉAIRE CANADIENNE

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Editorials

Yes, Minister

We really hate saying nice things about politicians – it spoils the whole day for us. But sometimes there's no help for it. And this is one of those times. In February, Ontario's Energy Minister was kind enough to address a meeting of the Toronto Branch. By just coming along he showed both courtesy and courage. Courtesy because CNS Branch meetings really aren't notorious for their provision of "photo opportunities" and "sound bites", those essential political nutrients. And courage, because chaps in the nuclear business are often less than totally friendly to politicians and have been known to ask pointed questions in an accusatory tone. (It may be they have some cause for such a predisposition, but that's neither here nor there).

The Energy Minister's talk dealt principally with Ontario Hydro. This was a perfectly legitimate focus in view of the fact that the provincial utility is the largest single user of CANDU technology. While most of what he said was generalistic enough to leave his ministry unembarrassed by any inconvenient specific commitment or policy, implicit in the talk was a very important, and potentially highly beneficial idea – that of more direct and specific government involvement in the energy business. As will be seen elsewhere in this issue, from the text of the Minister's talk and his response to questions it is clear that Mr Wong intends to see that the government generally and the Energy Ministry specifically is to become more involved at a more detailed level.

A groaning response that this just means an even greater tonnage of paper to be shifted about the place is inappropriate. Clearly the technocrats are going to have to start spending rather more time and effort in justifying their specific plans and this may well be a very good thing. It could achieve two very important objectives. One is a clearer understanding by the politicians of some of the technical realities of meeting energy needs – energy policies which at an early stage in formulation are informed by some degree of technical insight will be better energy policies.

And there's nothing wrong with the technocrats being required to re-examine and, if necessary re-justify, some of their tenets. It's a powerful counter to the dangers of intellectual ossification to which the organizations that make up the Canadian nuclear industry are no more immune than any other.

If this works – and there's no reason why, given modest effort on both sides it shouldn't – we may well have a valuable model for more effective government involvement in science and technology generally, which would be no bad thing.

So a tip of the hat to Robert Wong – we wish him, his Ministry and Ontario Hydro luck. We hope it works out well.

And another big wave of the titfer to the Toronto Branch by way of thanks for all their hard work in bringing us meetings such as this one.

Hit Him Again, Baby

The February 11 issue of the British weekly, *The Spectator*, carried a very hawkish article about nuclear energy. Perhaps even more significantly, because of the much wider readership, an edited version of the same item was carried in the February 13 issue of *The Telegraph*.

The message in both was clear and straightforward.

Coal is bad. Coal is a killer. Nuke is good. The horror stories about nuke are largely bunk, but largely true about everything else. The industry is poncing about instead of driving this message home hard.

These articles both drive their message home hard. They are strong personal testimonials by a nuclear engineer in an unidentified country who gives his name as Andrew Kenny. The writing is good. Hard-hitting. A blow to the groin follows a haymaker, and another objection is dispatched. One can almost feel a sympathetic jar as fist connects with jaw.

Strong, black and white statements of the virtues of nuclear energy doubtless have their place. What is less clear is whether such expressions of seemingly absolute certainty should be coming from industry spokespeople. Counter-arguments to this sort of hedging are probably not far off. Who else will make clear statements if not industry people? Why not fight back hard? We have a good product.

All true. Statements deriving from deep personal conviction are statements that should be made. But not everyone has the same approach to forceful statements. One can be passionate, articulate and convincing without being a thorough-going hawk. The objective, surely, is to provide information ensuring that the nuclear option is used judiciously as needed, and to keep sufficient numbers of minds open out there, with adequate, reliable lines of communication to those minds so that there is not a risk of the option being choked off by the effects of disinformation. Make the case too forcefully, however, and it may become the public relations equivalent of slash and burn: the land will be cleared fast but a great store of ecological damage may be laid up for the future. Another, and to many, a more appealing trail is the one blazed by Richard Crossman.

Crossman, who became a cabinet minister in Harold Wilson's government in Britain during the 1960s, had been in charge of the overseas services of the BBC during World War II. He had a simple and straightforward policy for broadcasting

information about the conduct of the war: make sure that your statements are so accurate and so reliable, even (perhaps especially) if you perceive the information in them to be unfavourable to you, that nobody can afford to disbelieve you, not even the enemy. This policy worked astoundingly well, and is possibly the most important reason for the traditional authority and high respect accorded to the BBC news services down to the present.

Possibly in its public statements the nuclear industry has been less forthright and blunt than was warranted in some cases, but it is not certain that a generally more hawkish stance would have done better. Statements made by nuclear scientists and engineers have often appeared to be timid, not because those people *were* timid, but because they were cautious. (Oh, how easy it is to carried off on a sea of one's own hyperbole, e.g. "too cheap to meter".) Thirty years of caution and circumspection has paid off in a superb product. Perhaps that caution is too good a source of golden eggs to throw away just yet.

Church opposes sin

The satirist, songwriter and mathematician Tom Lehrer once remarked of folk singers that "it really takes a lot of courage to get up in a coffee bar or a college auditorium and come out in favour of things that everyone else is against – like peace and love and brotherhood and all that sort of thing".

We have the same feeling when we examine the Ontario Select Committee on Energy report on Ontario Hydro's Draft Demand/Supply Planning Strategy.

This committee was established in February 1988 to enquire into and report on Ontario Hydro affairs. The Committee issued its report in January. According to their report the Committee chose to focus its attention on review of Ontario Hydro's draft Demand Supply Planning Strategy document using as a lens, among other things, six weeks of public hearings in which individuals and organizations made written and oral submissions on the Ontario Hydro document. The Commitee's report claims to provide "further guidance to the government, the Ministry of Energy and Ontario Hydro in the planning of Ontario's electrical energy requirements".

Before examining the nature of this guidance in any great detail it's a good idea to see what the thing was that the Select Committee looked at. According to a source at Ontario Hydro, the Demand Supply Planning Strategy document represents the end product of a four year study carried out by utility staff of the various factors influencing provincial electrical demand (including various demand-side strategies), the various options for meeting these demands and the extent (based on technical feasibility) to which different options might be usefully applied. It was, apparently, quite a detailed assessment.

The document was scrutinised by ten provincial government ministries and an independent technical advisory review panel (chaired by Carl Beigie) and the reports these reviews generated were supplied to the Select Committee.

Now the Ontario Hydro document may be an admirably objective and scholarly study or it may be a big pile of self-serving old cobblers – most probably it falls somewhere between these polar extremes – but the Select Committee recommendations give no indication. Indeed, a quick perusal of those recommendations leaves one in a never-never land of worthy precepts uninformed by any specific reference to any quantitative criteria, any Ontario Hydro proposal or anything else.

Consider the first recommendation:

In the planning for and meeting of Ontario's electrical energy requirements, Ontario Hydro and the government should place high priority on the maintenance, upgrading and refurbishment of the existing generating and related transmission system consistent with the highest standards of environmental protection

What a smashing idea! It's lucky, one reflects, that Ontario Hydro has the chance to receive such expert guidance. Or how about:

The environmental implications of candidate supply options must be a major factor in selecting additions to the Ontario power system

Bet Hydro hadn't thought of that one. But perhaps the best example of what we mean is recommendation No 25:

Ontario Hydro should give high priority to reducing uncertainty in its forecasting

That's just the sort of specific advice and guidance the juggernaut Hydro should be getting.

Let's be quite clear that no-one would dispute the fact that Ontario Hydro is a creature of the provincial government. And when the government says "jump" Hydro's response should be "how high?". But then the government should tell them how high. This Select Committee Report doesn't.

A good innings

In January this year Sir Thomas Sopwith died at the age of 101. To call his life a full one of magnificent achievement is, if anything, to understate the case. While his name is linked in the popular imagination almost exclusively with the Camel – the rotary-engined fighter that shot down more enemy aircraft than any other allied type during the First World War – he was a most prolific designer, providing the RFC and the RNAS with over 20 different aeroplane designs. This was a less exceptional achievement than the fact that all these designs saw successful squadron service. Foremost among

them were (in addition to the Camel): the Sopwith Triplane, flown by Lt Collishaw and his all-Canadian "Black Flight", and the Snipe and the Dolphin – aeroplanes which were the first implementation of the concept of the "heavy" fighter.

Following the War, Sopwith changed the name of his aeroplane company to "Hawker", the name of his chief test pilot. He also obtained the services of Sydney Camm. Since then Hawker aircraft have been in continuous service, from the Demon, Hart and Hind biplanes, through the Hurricane, Typhoon and Tempest of World War II to the classic Hunter jet fighter and, ultimately to the vectored thrust Hawker 1127 (most recently known as the Harrier). For about three quarters of a century airmen have been flying aeroplanes whose ancestry can be traced back to Tommy Sopwith.

It's pleasant to reflect that if there's an aviation Valhalla, one corner of it (a very large corner) will be quite crowded as Tommy Sopwith swaps tall stories with Cobham and Seagrave, discusses spin recovery with Lindeman and argues about fighter design with Mitchell. And listens with mixed tolerance and enthusiasm to the line-shooting of generations of airmen.

We'd like to think, too, that Sir Thomas would be pleased that a simple, but quite engaging, computer game involving World War One aviation is called "sopwith".

But what has all this do with us? Nothing except that we observe the passing of a great pioneer. Our world is richer for his stay in it.

From the Gallery

Jerry Crown and Patrick Gutteridge

Tritium Sales?

One of the most topical questions in the Ontario Legislature these days is the question of whether the Ontario Government will allow Ontario Hydro to sell the tritium it removes from heavy water that has been through the reactors.

New Democratic Party Leader Bob Rae led off Hydro-related activity in the Legislature in mid-February with questions on the possible sale of Ontario Hydro produced tritium in the international marketplace. Mr. Rae was following up on a press conference held by Durham Nuclear Awareness, which released a leaked Cabinet document recommending that Hydro be encouraged to sell tritium. Mr. Rae asked if Cabinet had decided whether Hydro should sell tritium. Energy Minister Bob Wong said that the matter had not been discussed, and therefore no decision had yet been made. Mr. Rae then asked the Minister to point out the federal regulation that would stop Ontario Hydro's tritium from freeing up U.S. tritium for military purposes.

Mr. Wong declared that "if we were to consider providing small amounts of tritium for medical research on cancer, or research on AIDS, or for safety reasons, for the production of signs, we would want assurances, not only at the federal level but also our own level, that stringent, proper, adequate safeguards were in place." Mr. Rae expressed scepticism that Hydro would be able to control its use, once out of the country. The Minister replied that "we might decide that the best option and the best strategy is to develop a strong industry within Ontario and within Canada."

PC energy critic Sam Cureatz, whose riding of Durham East is home to the Tritium Removal Facility, wanted confirmation of a rumour that the TRF was being shut down, at the same time that tritium sales were being discussed. Mr. Wong replied that the two issues are unrelated, but that the TRF would, in fact, be closing soon for maintenance to bring it up to the standards that Hydro wants to operate at."

New U.S. acid rain law?

President George Bush's statements that his administration will draft acid rain legislation increases the chances of action, but stops short of guaranteeing it, says an American Public Power Association staffer.

Introduction of a bill drafted by the White House would send a signal to Congress that the administration is amenable to legislation controlling acid gas emissions, Ruth Gonze, APPA's legislative policy analyst, said in an interview. However, asking Congress to consider yet another bill on the subject – even if it is from the administration – in no way ensures consensus on how to deal with the problem, she said.

Over the next several weeks, Congress will likely have four separate acid gas control bills to consider, not including any the administration may introduce. Congressman Jim Cooper, a Democrat from Tennessee, introduced the first in the House of Representatives on January 3. As with all bills expected to be tabled over the next several weeks, Cooper's calls for a minimum 10-million-ton reduction in emissions over the next 12 years or so. It would not require scrubbers for new or existing plants, but would impose expensive non-compliance penalties against states whose emissions exceed prescribed limits. The estimated annual cost of implementing the Cooper proposals is $2 to $6 billion. A moderate proposal, it is expected to receive serious consideration.

In a related issue, Senator Tim Wirth's massive, 150-page global warming bill is expected to be re-introduced. First introduced last August, it is unlikely to pass, although some of its provisions could be appended to bills that might. Some of these provisions are support for nuclear energy to displace fossil-fired generation; promotion of renewables and demand management; and the concept of "debt for nature" swaps, whereby the United States would forgive Third World debt in exchange for undertakings by debtor nations to preserve forests, or other such measures.

Jerry Crown is responsible for federal and international governemnt relations at Ontario Hydro. Patrick Gutteridge covers provincial government relations for the same company.

Number crunching or metal bending?

Marty Gavin

In order to get a license from the Atomic Energy Control Board (AECB) for a radioactive materials transportation container (or cask) it is necessary to demonstrate that the cask is capable of surviving a series of tests that simulate severe accidents.

The title of this article might suggest that there are two separate but equal ways to obtain such a license: computer analysis and physical testing. A careful reading of the AECB Regulations would suggest there are actually three ways – testing, analysis and reasoned argument.

Let's first dispense with the last one mentioned in the AECB Regulations, "reasoned argument". Given the ever more rigorous requirements for licensing, "reasoned argument" and $1.10 will get you a ride on the Toronto Subway. You can forget about "reasoned argument" unless the cask you are licensing today is virtually identical to the one you licensed yesterday. If the last licensing occurred the day before yesterday or earlier, you can probably forget this approach even if the cask is identical.

So now we have two choices, analysis or test.

Let's begin by talking about the marvellous advantages of computer analysis. Firstly, analysis lets you look at a number of alternative designs without the expense of breaking up a bunch of expensive hardware. Secondly, analysis provides an understanding of the physical phenomena that occur if a cask were to fail under accident conditions. A test will clearly demonstrate that a failure occurred, but won't necessarily show you why it failed. You can't fix what's broke if you don't have a clue why it broke (or at least it's a hit or miss way to do it). Thirdly, analysis will give you some idea about your margin to failure. Testing just gives a pass/fail grade.

So I guess that settles it. Computer analysis is the way to go. Well maybe there are one or two minor considerations we've overlooked. For example, analysis does a whizz-bang job of answering the questions you ask, but isn't worth a darn at answering the questions you're too dumb to ask. Inevitably we make modelling simplifications when setting up a computer analysis. Have we simplified in some important area? Or is there a failure mechanism that we never even thought about? It's remarkably difficult to model something you never considered.

Then there's the cost of large deformation finite element analysis. If you've cut your eye teeth on static analysis, you've got some surprises coming when you enter the esoteric world of large, rapid deformations. One of those surprises is that computer running time costs almost as much as throwing the hardware around the parking lot. Of course, you can trade the dollar cost of running on a mainframe by paying the time cost of running on a micro for an extended period. But regardless of the computer size chosen, there is a significant manpower cost involved in performing the complex modelling required as input to the program.

Oh heck! I guess that means we'll have to go the test route. Clearly that brings certain benefits. We'll find out very quickly if our analysis overlooked a failure mechanism. This can be a very humbling experience since expensive tests are rarely conducted in private. Further, a good, violent, metal crunching test is ever so much more convincing than a big stack of computer output. Demonstrating cask safety to the public is not an easy task when your only evidence is a morass of computer generated numbers.

But how do we know we've conducted the right test? The regulations clearly state that the cask must be dropped in the orientation that will produce the greatest damage. It's obviously too expensive to conduct a large number of tests to insure that we've got the right orientation. Oops, back to analysis again.

I won't bore you any further since I'm sure by now you've figured out the point I'm trying to drive home – i.e. computer analysis and testing both have a necessary role in modern cask licensing.

In reality the design and licensing of a cask goes typically something like the following:

One: A preliminary design on the back of an envelope.

Two: More detailed hand/calculator/personal computer calculations to confirm the worth of the preliminary design.

Three: Calculations to establish the worst test conditions. These calculations can be somewhat simplified since the goal is to find the relatively worst conditions, not to come up with absolutely correct results.

Four: Highly detailed computer calculations of cask response to the worst case accidents selected in step 3. These provide the nervous designer with a small shred of confidence before ...

Five: THE DREADED TEST! Here's where you find out if you thought of everything or if Mother Nature is about to teach you something that wasn't covered in Mechanics of Materials, 101.

... AND THEN EITHER:

Six (a): Smilingly receive your license from the regulatory authority

OR:

Six (b): Solemnly receive the ceremonial sword and instructions for its proper use from Joe Tanaka, the Supervising Samurai of Ontario Hydro's Radioactive Materials Transportation Unit.

If you want to start a good argument some Friday night over a beer, get your favorite number crunchers (analysts) and metal benders (testers) to discuss the place of their craft in cask licensing. But if you happen to be a cask designer, don't take sides. The truth is you're going to need them both.

Marty Gavin is a Nuclear Design Engineer (specialist) with Ontario Hydro's Nuclear Materials Management Department.

Technical Note

Treading Warily with Safety Culture

Keith Weaver

Overview

In the business and management environment, a recent concept which has been used to designate all those subtle influences not easily quantified and sometimes not even easy to define, but which seem to have a bearing on how well a company performs and adapts, is "corporate culture". Judging by the mileage it has seen in management consulting and other business fields, there are evidently those who believe that "corporate culture" is a useful and meaningful term. Over the past few years, a similar term, "safety culture", has been used increasingly in the nuclear safety context. Although it is seldom defined, in most instances it appears to refer to some desirable state of an organization in which all individuals have an awareness of the importance and significance of safety, and all activities are carried out with safety as one of their objectives. Terminology incorporating the word "culture" may be useful in management consulting and other similar fields, but its appearance in the nuclear safety literature, most notably in the IAEA specialists' reports on the Chernobyl accident, invites closer scrutiny.

This note discusses the meaning and usefulness of the term "safety culture". The starting assumption for the discussion is that the introduction of any term such as "safety culture" should at least (a) help clarify or pinpoint a problem area more precisely, or (b) help point the way toward a solution to some existing problem. The conclusion of the discussion is that the introduction of "safety culture" does not obviously lead to either of these objectives, and that it may even have a potentially negative influence. An example is presented as part of the discussion, the King's Cross fire in the London Underground, to give a specific instance of how such a negative influence might become manifest.

There is no intent, in what follows, to deny that some sort of guiding ethos is necessary or desirable, to inspire individuals and organizations to strive for increased safety. However, the business of directing and focussing this effort, of actually bringing about demonstrable improvements in safety, is intensely practical and requires very clear definition of terms. Because of this, it is important to try to understand just how "safety culture" fits into the overall effort.

"Culture", in all its senses, denotes a state of affairs that cannot be posited, postulated or promulgated into existence. It has to grow on its own. In contrast, the elements, activities, etc. on which a culture is based occur for specific reasons or can be undertaken by conscious decision. In the nuclear safety context, it is these underlying activities which are important because they are the immediate factors involved in bringing about an improved state of safety, and it is obviously the attainment of increased safety which is the primary objective, not the attainment of a healthy "safety culture". Also, of the two concepts, it is safety and the means of studying it which can be defined and grasped relatively clearly, whereas "safety culture" can be understood only in a very foggy way.

Thus, "safety culture" can be viewed as a collective or common state of mind which exhorts everyone to insure that an awareness of the need for increased safety is a guiding factor in all activities. In this role, it can only provide the motivation toward increased safety. This by itself is obviously not sufficient and there has to be also insight and direction toward some immediate safety-related goal, as well as the means to get there. To the extent that a concentration on "safety culture" deflects effort away from determining what needs to be done and finding ways of doing it, then the effect of "safety culture" could be questioned.

A principal objective of the present note is to suggest that the frequency with which the term "safety culture" appears in discussions of nuclear safety may indicate an undesirable preoccupation with the term "safety culture" itself. Such preoccupation may occur specifically because any understanding of the term is intrinsically vague. Concentrating too much on "safety culture" may not only detract from the main task but may also foster the impression that something adequately rigorous and effective is in place and functioning, when in fact this may not be the case.

The discussion which follows is in four main parts.

Different Kinds of Safety: In the first part, it is noted that the appearance of "safety culture" in the nuclear safety context, follows paricularly in the wake of the Chernobyl accident. Although, as a principle, "safety culture" is expected to be applicable to all aspects of nuclear safety, it is clearly intended to contribute to a reduction in the frequency of devastating high consequence events. An attempt is made to contrast the sorts of actions to which a "safety culture" might lead in different situations, and the unique problems of predicting and avoiding low probability events are highlighted. In particular, the application of any preventive measure as would be envisaged under a "safety culture" is compared for the cases of low and high probability events. The concerns being raised in this portion of the discussion can be summarized by the following questions:

Exactly what problems are the elements of a "safety culture" trying to avoid?

How do we know that these are the problem areas that need to be avoided most?

How do we know that the proposed "safety culture" will actually lead to these areas being avoided?

In other words, if the entire complex of organizational and management structures is to be brought formally and systematically into the quest for improved safety, then a necessary

first step is to understand in what ways these structures may promote, impede or even degrade the safety effort, and just what changes are needed to strengthen the positive influences and remove any impeding influences.

Too Many Definitions: The second part of the discussion concentrates on the word "culture" and the demonstrable problems which exist in defining it. Unless this term can be defined clearly enough in the restricted subject area of nuclear safety, while at the same time excluding the ambiguities which have accompanied it in other contexts, the whole project of defining and instituting a "safety culture" is seen to be in some doubt.

A Practical Instance: The third part presents an illustrative example (the King's Cross fire) bringing out some of the points made earlier.

Discussion and **Summary** sections constitute the fourth part.

In its most recent statement on the topic, the IAEA has noted[1] that one attribute of an organization which should be fostered by a "safety culture" is an "inherently questioning attitude". It is in this spirit that the present discussion is intended.

Different Kinds of Safety

A convenient starting point is to note that there are three distinct safety issues which might legitimately be considered under the term nuclear safety. These are public safety, occupational safety and protecting the plant against damage. The first two include both chronic and acute components, whereas the last-mentioned is concerned only with acute events (in the sense that threats to the health and safety of people are more likely to result from serious plant events, while milder events are more likely to represent an operational concern). As a preface to what follows, the contention here is that a term such as "safety culture" can have very different implications in the occupational and plant protection contexts and that the specific definition of "safety culture" will vary with the context.

One way in which public safety and occupational safety are distinguished is that the public has no direct control over its level of risk (either chronic or acute) from a plant. Since the term "safety culture" was clearly not intended to apply to the public, however, public safety will not be discussed further.

In contrast, occupational workers can have some control over the chronic threat to their level of safety, but probably less control over the acute threat. Events such as "man drops hammer on foot" are acute to the owner of the affected foot, but are chronic in the statistical sense that they happen fairly frequently. Their rate can be reduced, but it cannot realistically ever be reduced to zero. Reductions in the frequency of such events are possible because the events in question (or similar events) have occurred frequently enough in the past for an understanding of their causes to develop. Out of this understanding, safety equipment and appropriate work practices can be evolved to avoid such accidents or to mitigate their consequences. Promoting an awareness of the need for using this equipment and adopting these practices could be one aspect of a "safety culture".

Protecting plant from damaging accidents is different from occupational and public safety activities in two significant ways.

First, the nature of the safety concern is different. The plant itself is the object to be protected. It has no vested interest and no strong feelings either way. Some individual, or individuals, who do not own the plant, must take responsibility for keeping it free of accidents. So while the concern for an accident-free plant may be strong, it will be different from that of a worker for his own health and safety. This concern for plant protection may also be diffuse and fragmented, since many people are needed to ensure the safety of a large plant even if one person is ultimately responsible.

Second, as already mentioned, plant accidents are chiefly an acute concern, since minor plant events are unlikely to represent a threat either to public or occupational safety. The occurrence of accidents may be connected with public and occupational safety, but this is not necessarily the case. In an accident, the plant may be destroyed with no significant occupational or public consequences, as happened at Three Mile Island. More important, being an acute phenomenon, major plant events are by nature a low probability, high consequence problem. The important term here is low probability. This is at the other extreme to "man drops hammer on foot" and workers can have little or no personal knowledge of plant accidents since they occur too rarely for anyone to have any significant experience of them. In the "man drops hammer on foot" case, a statistical understanding of the hazard allows effective rules to be developed. It is soon evident whether such rules (e.g. use of safety shoes) are effective because the events occur frequently enough that any change brought about by a new rule will show up in the statistics fairly promptly.

In the context of major plant events, there is either a very sketchy statistical data base, or none at all to start with, because of the rarity of the accidents. No rules can be drawn up, based on experience. Even if rules that seem to be reasonable are formulated, their effectiveness cannot be demonstrated from experience for the same reason: lack of data. It is hard to modify one's activities in such a way as to avoid plant accidents when one has no personal knowledge of them, what causes them, or what to do if such an accident seems to be happening. The ultimate objective of a "safety culture" is presumably to establish those conditions which will influence behaviour in such a way as to reduce the likelihood of plant accidents. The question, then, is how to determine what are the conditions which lead to safe operations.

It seems apparent, also, that any set of rules will depend on the situation. If something called "safety culture" exists in the plant accident context, it may be quite different from an occupational "safety culture". Neither the IAEA documents nor any other publications that I am aware of in which the term "safety culture" has appeared, have made a distinction between the occupational and plant accident contexts. Is a "safety culture" in one of these contexts likely to differ from that in the other? I suspect the answer is yes.

The objection could be raised at this point that the analysis of accidents does provide some knowledge of their causes and signs, and that what should be included in a "safety culture" could be deduced from a study of the findings of existing

accident analyses. This is true, to the extent that accidents are "caused" by the sorts of mechanical problems which existing analytical methods try to seek out. But "safety culture" is taken to include other functions in the organization as well, and to the extent that these functions may be implicated in accidents[2] their influence on the analytical findings and conclusions has to be considered.

In one sense, the analysis approach reduces to the "real life" case. Analysis is used to build up quickly a surrogate experience of accidents. In order to check the degree to which this surrogate matches the "real world", both in accuracy and completeness (especially in the regions of low probability events), comparisons with empirical data are needed, but this puts us back where we started. Thus robbed of feedback, we cannot confirm, in any overall or high level context, the effectiveness of any preventive measures drawn from our surrogate experience. The statistical problem remains, but it is unavoidable. While the information derived from existing analysis is the best available, it still may be insufficient to establish what should form the basis of a "safety culture".

Too Many Definitions

In addition to the above problems in defining the term "safety culture", there are two reasons why the use of the word "culture" in the context of nuclear safety is inappropriate. One reason is that "culture" is a term already charged with meanings but these meanings apply to areas completely unrelated to the technical sphere presently under consideration. When the word "culture" is used in such a technical context, there is a clear possibility for confusion with the area the word normally signifies, i.e. the general cultural system in which we all participate. At a deeper level, when one tries to pin down more precisely the intuitive notion that everyone has of "culture", in its everyday sense, the real complexity of this anthropological aspect of the term becomes apparent. In one book, now rather aged, two anthropologists of considerable stature have catalogued over 150 distinct definitions of "culture".[3] A more recent work [4] which has attempted a precise definition of "culture" needed a total of 35 subsidiary definitions to be complete. This only underlines the complexity of the reality which the term, used in its familiar social or anthropological sense, reflects. The presence of such demonstrable complexity should make it clear that attempts to transplant the word "culture" could be risky. To use such a term, which has already spawned so many definitions, in a sphere outside that in which it has conventionally been used, and to describe a much more restricted situation, seems unwise.

The second, and similar reason, why one should probably avoid the word "culture" is to head off any confusion with "corporate culture" used in management circles, as noted above. It may seem strange to want to do this, because at first glance the two may appear to have a lot in common. This first impression may be wrong. By virtue of its appearance and sound, "corporate culture" has a rather trendy alliterative ring. This might lead one to suspect, rightly or wrongly, that its use is trendy as well and that it is still in its infancy, and prompt one to wait to see whether it becomes more precisely understood with use and discussion or falls out of currency. Is the term "safety culture" likewise just a trendy member of the "culture" family?

For purposes of completeness, and without claiming sympathy with the concept, one can describe the meaning ascribed to "corporate culture". The use of the term in its management sense is intended to provide a label and a concept which can describe a whole nexus of phenomena or influences that are present and at work within a company. These phenomena or influences may affect the ability of the company's managers and staff to recognize and to react to those things which have a bearing on how well the company meets its objectives. Only a few of these factors may be important, the so-called "success factors".[5] These may vary from company to company and they may also vary with time within one company. The uncertainty that business managements face every day, and the empirical use of flexible concepts such as "corporate culture" are perhaps an appropriate match. In this sense, the apparently necessary ambiguity in "corporate culture" reflects a similar ambiguity in the unmodified "culture". This ambiguity may arise because of the situation which the term "corporate culture" applies to, but it is more likely just definitional baggage accompanying the word "culture". By comparison, the stringency that would be expected in a nuclear safety context is likely to be a far different matter. Viewed thus, the two desired outcomes, "ensuring corporate success" and "preventing accidents at nuclear power plants", may have more differences than similarities.

A Practical Instance

The preceeding paragraphs have outlined some of the problems which seem to be involved in formulating a clear definition of "safety culture". The King's Cross fire in the London Underground in 1987 will now be discussed briefly to indicate at least the possibility that the incautious use of a term such as "safety culture" may present an active danger.

At about 7:30 on November 18, 1987, a fire began in one of the escalators in the King's Cross underground station. Within fifteen minutes, a flashover occurred in which the fire expanded from its relatively localized area on the escalator and engulfed the ticket hall of the station. Thirty-one people were killed and many more were badly burned.

In his report,[6] the investigator tried to answer three questions: How did the fire start? Why was there a flashover? and Why did 31 people die? Some of the answers to these questions will be summarized from the report very briefly.

The fire was started by a match which was dropped on the escalator treads and fell through a gap into the equipment space below. In this space were the running tracks for the escalator. These tracks should have been cleaned regularly but had not been and a thick deposit of grease, lint, fibrous material and dust had built up on them. When someone leaving the station noticed a fire below the escalator, one of the station staff was informed. He went to investigate but he had had no fire training and he did not report the situation to either the station manager or the line controller.

London Underground had no evacuation plan. There was no effective communications system in place. Two policemen inside the station had radios but they had to come above ground for them to be usable. Trains kept stopping at the platforms below because there was no fast way of warning drivers not to stop and let people out at King's Cross. There were

water spray systems and hand held extinguishers in the station but neither were used because none of the staff had any instructions or training in their use. The police and fire brigade did not know the geography of the five levels of tunnel in the station. The first fire engines arrived only two minutes before the flashover (because they had not been called when the fire was first noticed) and by then it was too late for them to take any effective action.

The investigator's report makes several things clear. In his view the principal lesson to be drawn is that the right approach to safety was not used. He describes what he means by this at length in one of the chapters, but notes specifically that an insufficiently high priority was given to passenger safety in stations because no one person had overall responsibility for safety. Instead, too much credence was implicitly placed in what the investigator calls "the ethos of London Underground". "London Underground believed that safety was enshrined in the ethos of railway operation" and this allowed a blind spot to develop over the hazard of fires on escalators.

This belief in the safety ethos was so strong that it allowed London Underground officials to overlook danger signs. Other fires had occurred in the immediate past. (There was an insistence that these should not be called fires but "smoulderings", and should be regarded as an occupational hazard.) These earlier fires had not killed anyone, and London Underground officials believed that with all the staff and passengers available as "smoke detectors", any fire would be identified early and there would be plenty of time for evacuation. This false sense of security was apparently reassuring enough that the lack of any system of staff fire drill or evacuation training was able to pass unquestioned.

While several *caveats* are necessary, and while this accident is not directly comparable to a nuclear situation, one can nevertheless draw some warnings from the King's Cross fire.

In the extreme case, the "ethos of railway operation" and "safety culture" might be regarded as roughly equivalent formulations when it comes to large consequence low probability events (i.e. plant safety with implications for public safety). Both are vague umbrella terms which serve as labels designating an approach to very complex situations. Everyone "knows" what they mean until the time comes at which that meaning has to be translated into specifics. When the crunch comes, however, it may be realized that they are virtually meaningless terms and can provide no detailed guidance.

The King's Cross situation may also indicate a case of assuming that the absence of accident data points means confirmation that whatever measures are in effect (e.g. the "ethos") are working. The non-occurrence of an event requires an extensive record in order to validate a claim that the probability of the event occurring is less than a certain value. In a rather simplistic way, it can be demonstrated, using the Poisson distribution, that about 300 years of observing that an event has not occurred is needed to conclude at the 95% confidence level that its probability of occurrence is less than once per hundred years.

Using the King's Cross experience as a guide, the danger in using a term like "railway ethos" or "safety culture" appears to derive from at least two sources: it may produce a false sense of security and of preparedness and it seems able to form the basis for an outlook which may be hard to change. Both these factors were demonstrated in the King's Cross fire.

The false sense of security was noted by the investigator as leading to a blinkered approach to fire safety on escalators, but it could well have produced impaired vision in other areas too. The outlook as to how safety should be managed by London Underground was present both before and after the fire.

Concerning conditions before the fire, the testimony of one of the London Underground officials is referred to. The report notes:

Mr Lawrence testified that as his predecessors and senior managers had been satisfied with the processes in place, he would have found it very difficult to say that the system in place was inadequate. Yet a series of reports from within London Underground and from outside had repeatedly drawn attention both to the lack of training in emergency procedures and to the fire hazards on the system.

Even after the fire, similar attitudes persisted. The report states:

It was, therefore, a matter of some concern to me (i.e. the investigator) *that the directors of London Underground should still subscribe to the received wisdom that fires were an occupational hazard on the Underground. Dr Ridley did not feel able to agree with the Court that fire should be regarded as an unacceptable hazard to be eliminated, since it was considered that fires were a part of the nature of the oldest, most extensive underground railway in the world.... In effect he was advocating fire precaution rather than fire prevention.*

Discussion

Much of the foregoing may seem rather negative, and so it is. What positive elements might be drawn from it?

It must be acknowledged that the discussion presented above on accident analysis was somewhat harsh. It is, in fact, undeniable, that those industries which have active safety study programmes also have good safety records. It would be difficult to maintain that safety and accident analysis have not played some role in this. The reason for these safety benefits is surely that the approach to studying safety and applying the results has been thorough, systematic and painstaking. The definition and application of anything called "safety culture" would have to be equally exacting.

It would also be wrong to infer from all this that an awareness of the need for safety is not necessary. Engineers, to cite just one group, have long had a strong commitment to competence and safety. This commitment is partly reflected in codified statements of responsibilities and ethics. Is something called "safety culture" needed in addition by this group? If so, how does it differ from the existing statements of commitment? What are the analogous situations with other groups?

The most recent IAEA statement on "safety culture"[1] includes much more description of what is meant by the term than have previous statements. Does the presence of this additional material vitiate the criticisms expressed here?

In this statement, "safety culture" appears as a subheading under Management Responsibilities. It is worth quoting at length from this sub-section.

Safety Culture

Principle: An established safety culture governs the actions and interactions of all individuals and organizations engaged in activities related to nuclear power.

The phrase 'safety culture' refers to a very general matter, the personal dedication and accountability of all individuals engaged in any activity which has a bearing on the safety of nuclear power plants. The starting point for the necessary full attention to safety matters is with the senior management of all organizations concerned. Policies are established and implemented which ensure correct practices, with the recognition that their importance lies not just in the practices themselves but also in the environment of safety consciousness which they create. Clear lines of responsibility and communication are established; sound procedures are developed; strict adherence to these procedures is demanded; internal reviews are performed for safety related activities; above all, staff training and education emphasize the reasons behind the safety practices established, together with the consequences for safety of shortfalls in personal performance. . . .

. . . By these means, an all-pervading safety-thinking is achieved, allowing an inherently questioning attitude, the prevention of complacency, a commitment to excellence, and the fostering of both personal accountability and corporate self-regulation in safety matters.

There is nothing wrong with these statements. They are all valid, as far as they go. In rephrasing this quote and taking it further, something like the following could be suggested.

1. In organizations responsible for nuclear power plants and their operation, there are people whose functions are important for the safety of those plants. These functions may include the highest levels of management and range throughout the organization. There is a need to identify all these functions and specify in what way each of them is important for plant safety. The information required for this must come, by default, from the insights of the existing body of analysis. This analysis would have to be extended from the present relatively narrow technical focus to encompass the various roles of the organization in safety.

2. Having identified the important functions, the safety-related duties and responsibilities residing in those functions have to be laid out as clearly as possible. This should include a statement of the practices and situations which are to be avoided, according to what priority they are to be avoided, the reasons why they should be avoided and how the correct discharge of the specified duties and responsibilities will help avoid them.

3. There needs to be some system to measure and judge how well the duties and responsibilities thus identified are being discharged.

This sort of approach is analogous to that used in the achievement of mechanical safety and reliability. If a range of other functions, in addition to the traditional technical disciplines, are equally important to safety, then perhaps an equally rigorous and systematic approach is also needed to deal with these additional functions. If this is the case, then the problem at hand is, first, to understand thoroughly the implications of those functions for safety, and second, to devise means by which their positive influences can be strengthened and any potentially negative influences suppressed.

Where does this leave "safety culture"? At present, it is a term that "refers to a very general matter". Does it clarify the situation in some regard, or is it just a general label to be applied to a vaguely defined area? If the term "safety culture" is invoked, but if further and more detailed definitions are then needed to describe what it is and how it should work, then those definitions really ought to come first. For the moment, "safety culture" seems to be a name looking for a home.

Summary

There is no question that the perceived need for a term such as "safety culture" reflects the general desire in the nuclear business to see safety levels increased. The discussion here is not about motive but rather about definitions, and the questions being raised are, Just what does the term mean? and, Does its presence point the way to improved safety? It has been pointed out that even with the motivation supplied by "safety culture", finding the direction toward increased safety and the means of getting there are tasks that still remain. Arguments have been presented to indicate the importance of insuring that something called "safety culture" does not become the *sine qua non* of nuclear safety. It can help to inspire, but more importantly it must itself be inspired by, a pre-existing thorough and systematic programme aimed at uncovering and eliminating all the causes of accidents. As "safety culture" is presently viewed, i.e. as a sort of prime mover or catalyst for safety, it may not help and may possibly hurt the overall effort.

Arguments have been advanced suggesting that safety studies and related activities must form the solid and comprehensive basis, out of which any sort of general awareness of and felt need for safety can grow. It has been suggested that the ambiguities inherent to the term "culture" may be ineluctable, and that this condition may be a trap for the unwary. It has been noted also that there are further questions which need to be broached. What subsidiary definitions are needed for a full understanding of the scope and significance of the term "safety culture"? Does the term reflect the clear understanding of a concept? What changes would an established "safety culture" bring about? What specific problems does it

seek to avoid? How do we know that these are the problems that need to be avoided most? How do we know that a proposed "safety culture" would in fact result in these problems being avoided? How does one set about establishing a "safety culture" and how does one test periodically to see that it remains in good health? Is it not an assumption that the establishment of something called a "safety culture" is expected to lead to the adoption of safe practices on the part of individuals presently outside the ambit of formal safety analysis, but whose contribution to safety may be significant?

Because of questions such as these, one should approach with extreme care the use of any poorly defined portmanteau term such as "safety culture" in a nuclear safety context.

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Special Report

Managing the Present, Planning the Future

Talk given by Ontario Energy Minister Robert Wong to the Toronto Branch of the Canadian Nuclear Society, 15 February 1989

I try not to be a difficult person to get hold of, but these are very active times at the Ministry of Energy – that's why I want to thank the Canadian Nuclear Society for changing the date of the meeting so that I could be here. I felt it was important for me to come here today rather than send a substitute because your work in the nuclear industry is vitally important to the energy future of Ontario and also to Canada.

Today I want to give you an overview of the government's role in the electricity business in the province. I would like to communicate to you what we're doing and where we're going and why we're heading in that direction.

My job is, of course, to look at the overall picture of the province's energy landscape. My ministry's mandate is to ensure that we have safe and reliable supplies of energy obtained at reasonable cost. And however we generate that energy – in the case of electricity – that we do it in a socially acceptable way. Electricity is only part of the picture, I should point out. It accounts for approximately 18 percent of the consumption picture in Ontario. Ontario is the largest energy consuming province in Canada – $13 billion is our annual energy bill – and 80 percent of that is in oil and gas which comes from outside the province.

But electricity is the only form of energy that we produce on a large sacle, entirely within the province. And it's an energy form upon which our industry and our life-styles are dependent. One of our goals is to avoid undue dependence on outside sources of energy, so we must begin with wise electricity development and use.

I recently tabled legislation that will take this province a step in that direction. I am referring to a set of amendments to the Power Corporation Act, which is the legislation that defines the relationship between the government and Ontario Hydro. When the legislation is passed it will define a new relationship in which Hydro is more responsive to government policies and public priorities. I'll have more to say about what the new relationship will accomplish and how a bit later. First I want to give you a brief look at how we reached the point where this set of changes was necessary.

The amendments represent the first major overhaul of the Act in 15 years. But Ontario Hydro goes back much further than that. In 1905 Ontario's Beck Commission, named after its chairman Adam Beck, endorsed the idea of a publicly owned power system. Based on that the government of the day passed the Power Corporation Act the following year, creating the Hydro-Electric Power Commission of Ontario.

In 1971 a review, called Task Force Hydro, came up with recommenations to make the Power Commission more responsive to Ontario's needs. That led to the last major review of the Act in 1973. Hydro was changed from a Commission to a Corporation, with a chairman, a board of directors and a president. At the same time the Energy Board Act was amended so that the Ontario Energy Board would review Hydro's electricity rates. And the government also created the Ministry of Energy so that it could deal with policy on all forms of energy under one roof.

I am not here to criticise those measures as wrong for those times. Indeed, the idea of Hydro working as a corporation with a board of directors is a sound one. And I am certainly going to be the last person on earth to criticise the formation of the Ministry of Energy! But from that time until our recent amendments, the legislation had not been given a major overhaul.

There were some amendments made in 1981. One of them expanded the business of Hydro to include energy conservation programmes, plus production, sale, supply and delivery of heat energy. The other provided for rate assistance to rural

customers. By and large, though, the Act remained essentially the same.

The recurring themes in early reviews and independent criticism had seen the need for effective government direction of Hydro affairs. Reviews also suggested a planning approach that emphasised demand management and conservation. Many of our initiatives have been geared toward those goals. Early in our mandate we subjected Ontario Hydro's draft Demand/Supply Planning Strategy, known as the DSPS, to careful review. There were two reviews, one by a dozen government ministries and another by an independent technical advisory panel. In its review the independent Electricity Planning Technical Advisory Panel recommended a thorough enquiry be made into CANDU nuclear costs. It was a good idea and we went ahead with it. I expect to be able to report on this study in the near future.

I also tabled in the legislature a report on the safety of Hydro's CANDU reactors. The CANDU system has, since its inception in the 1950s, proved itself both efficient and safe. The report, written by Professor Kenneth Hare of the University of Toronto, independently reinforced this view. And it also identified problems that demanded further study and improvement. Dr Hare's report concluded that Hydro's reactors are being operated at high standards of performance and safety. Both it and the findings of the CANDU cost enquiry will be considered as we plan the future role of the nuclear option.

And now we have the latest development – our recent review of the Power Corporation Act. One significant amendment calls for a new Memorandum of Understanding between government and Hydro. The Memorandum, along with the amendments, defines a new relationship in which Hydro is still at arm's length from government, but the arms are a bit shorter.

From now on government has the authority to issue policy statements that Hydro shall respect in matters relating to Hydro's exercise of its duties. In plain English, what that means is if the government issues a policy statement to the utility then Hydro will do its best, leave no stone unturned, to meet the government policy. Government also has the authority to require Hydro to submit its plans and reports for review.

To keep information flowing properly the new relationship creates a system of consultation and reporting from Hydro to government giving government early access to information for review and comment. Hydro will provide the government with all necessary information on its plans early enough for legislators to make the best possible decisions about our energy future. That requirement is a new one.

Hydro will also keep the government fully informed of its progress and plans for meeting environmental protection goals. That is spelled out for the first time also.

In addition there will be a Hydro Committee, comprising a number of senior cabinet ministers, chaired by the Premier. It will meet regularly with the Chairman and President of Ontario Hydro to ensure that Hydro is responsive to government policies and priorities.

There's a lot more in the amendments, but I think you get the idea of where we're heading to try to ensure that Hydro, an agency of government, is more responsive to government objectives. But Hydro will still operate as a corporation with its government appointed Board of directors. Hopefully we're getting the best of both worlds – Hydro operating with the efficiency and effectiveness of the private sector while at the same time retaining its responsibility as an arm of the government.

In many ways Hydro is a good organization, well run and beneficial to the province. It does many things extremely well. But the time has come for Hydro to work more closely with the government in recognition of the government's responsibility to steer Ontario in the right direction as far as energy is concerned.

But what direction will we take? That is what I would like to address next.

The early development of the electricity system in Ontario was characterized by supply development. From time to time in the future there will be need for more supply projects. But the fact is, because of the changes in thinking, we can no longer afford to let our use of energy rise out of control. The environmental consequences of this approach are too severe. As we race to meet the next century we must take the responsible approach to energy. We have to balance our society's demand for energy against the environment's ability to survive the onslaught of our technology.

Environmental concerns have risen to the fore. That is one reason why the direction we are taking is toward more demand management and energy efficient programmes. Economic activity and environmental consequence go together therefore economic planning must reflect that.

This is the direction we are taking in Ontario and increasingly in Canada. At the federal-provincial level I will co-chair the annual energy minister's conference this coming August. The theme of this conference is energy and the environment. Among other points, I look forward to seeing the federal government give the environment the high priority it deserves.

I also sit on the Premier's Round Table on the Environment and the Economy. The mandate of this body is to find practical ways to implement the sustainable development concepts of the Report of the World Commission on Environment and Development. You may know this as the Brundtland Report.

In our legislation and programmes Ontario is taking the lead in seeking the responsible energy pathway. For example, as I mentioned earlier, objectives to preserve the natural environment are built into the new Memorandum of Understanding. Our Energy Efficiency Act, passed last summer, is another example. It requires that a number of major appliances and energy-consuming products sold in Ontario adhere to energy efficient standards which we are now developing. This is the first such legislation in Canada.

In addition Ontario Hydro has programmes to help their customers reduce energy demand. For example, Hydro has come to agreement with the Municipal Electric Association and the Association of Major Power Consumers of Ontario on time-of-use rates. These rates encourage efficiency by giving a price break to industrial customers when they use electricity during off-peak times. It works the same way as Bell Telephone's discounts on long-distance calls.

The Ontario government also has other programmes to encourage energy efficiency in municipalities and industry.

Responsible use of energy is the intelligent pathway toward sustainable economic development. But it is not the only reason why we are working to improve Ontario's energy efficiency.

Another important reason for this is that we compete with other countries in the international marketplace. Many of them, such as Norway, Japan and the United States have made much faster progress in energy conservation and efficiency than we have over the last 15 years. We must close that gap. If we don't our goods will simply be too expensive. Other countries have access to the same production technology and automation, and some of our major competitors have lower labour costs. If our economy is to control costs to remain competitive we must reduce energy costs.

On the up side, by keeping our industry competitive we can maintain and develop our economy and our standard of living.

It is when we turn our attention to new generating capacity for the future that your work dovetails with our environmentally sensitive outlook. It is clear that nuclear electricity from CANDU systems already plays a major role in our energy mix and will continue to do so in the future. With Darlington coming on-stream within the next few years, over 60 percent of our electricity will be nuclear.

In the next century our energy mix will also include such things as private generation – in the form of small hydro and cogeneration – wind energy, solar, geothermal and other non-nuclear energy sources. But those methods cannot produce energy on the scale we need today to feed our rapidly growing economy. Increasing our reliance on fossil fuels has its problems, not the least of which is the long-term uncertainty about the future of the global climate. Additional hydroelectricity is limited in supply since most of our large-scale hydro is already developed. There is still undeveloped small-scale hydro and the government is encouraging its full development along with Ontario Hydro.

CANDU nuclear electricity remains one of Ontario's options for large-scale capacity. That is why your job is so important in the future of this province and this country.

We must work toward providing better alternatives to future generations than the ones we must choose from right now. And in fact there is one resource, still in the experimental stage, which has the potential to help fulfill our future energy requirements.

I am of course referring to fusion power. Canada is playing a significant role in the international effort to harness this new form of energy which has the potential to be sustainable and have a relatively low environmental impact. Canada has an active research programme, called the National Fusion Programme. The Ontario component of this, called the Canadian Fusion Fuels Technology Project, is designed to further develop this country's expertise in fusion fuels technology and to mesh our work with fusion machine research programmes in other countries.

Our interest in fusion was underscored last year, when Premier Peterson wrote to Prime Minister Mulroney about the International Thermonuclear Experimental Reactor project, known as ITER. The ITER project will be the vehicle for cooperative fusion reactor development between Europe, Japan, the Soviet Union and the United States.

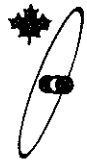
In the meantime your job is to work with the nuclear technology we have to continue to ensure that it is the best it can be. I cannot overemphasize the importance of this work. Those of you who work in the nuclear industry will ensure that our nuclear option can continue to fulfill the role set for it. That is the essence of your job.

The government's job is to facilitate change where change is needed and to ensure that, as the electrical system of the province develops, the alternatives are all adequately evaluated and weighed. And it is the government's job to ensure that concerns about safety, about the economy and about the environment are adequately addressed.

If we do our jobs together, in cooperation, we can see to it that our energy choices in the future are made with the greatest respect for the environment and in the best interests of Ontario, Canada and the World. It is very definitely a job worth doing and worth doing well.

With the development of these choices in mind, you may be interested to know that the Ontario Ministry of Energy, together with the Canadian Energy Research Institute, is sponsoring a two-day conference on Ontario's Energy Choices this coming April. I'd like to take this opportunity to invite you to attend.

Energy choices, we believe, is an important area for all the people of Ontario. Business and industry as well as government at all levels need to focus attention on this area because of the need for appropriate, proper electricity planning to take this province from now into the year 2000 and beyond in terms of the demand management side and the supply side options. This is the time we really have to get serious about what the alternatives are so we can weigh all the different options.



TECHNICAL SUPPLEMENT

CNS Bulletin March/April 1989 Canadian Nuclear Society

THE NUCLEAR FUEL CYCLE AND FEDERAL REGULATION, INCLUDING FUTURE TRENDS

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Ottawa, Ontario

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ABSTRACT

The radiation protection aspects of the Canadian Atomic Energy Control (AEC) Regulations reflect to a large extent the recommendations of the International Commission on Radiological Protection (ICRP). However, the Atomic Energy Control Board (AECB) also applies its own extensive experience with the nuclear fuel cycle when formulating these Regulations. This paper discusses the extent to which the current Regulations and the proposed General Amendments to the Regulations reflect current ICRP philosophy and outlines the possible direction of future regulatory action.

HISTORICAL

The Atomic Energy Control Act was proclaimed in 1946. It established the Atomic Energy Control Board, giving it a mandate to control and develop nuclear energy. (1) Regulations under the act were promulgated in 1947. These reflected post-war concerns and gave the AECB wide powers such as those to requisition the title to any prescribed substances and any patent rights related to atomic energy and to expropriate any mines, deposits or claims of prescribed substances. In 1954, the Act was amended to limit the Board to control, i.e. regulatory functions, leaving the promotional functions to the Minister designated under the Act. The AECB's initial concerns were with security and secrecy of nuclear activities; however, with the 1960 regulations made under the Act (2), the emphasis began to shift towards health and safety.

The next major change was made in 1974 (3) when the term "nuclear facility" was defined for the first time. It was defined as: "a nuclear reactor or accelerator, an enrichment or separation plant, a heavy water plant or a waste disposal plant". In 1978 the definition was widened to include more clearly uranium and thorium mines and mills and waste management facilities. (4) The AEC Uranium and Thorium Mining Regulations were promulgated in 1988 (5) and will be consolidated with most of the regulations made under the AEC Act. Currently, General Amendments to these Regulations are being prepared for the legislative process, following completion of public consultation and consideration of the public comments. (6)

THE AECB LICENSING PROCESS FOR NUCLEAR FACILITIES

A basic objective of the AECB regulatory activity is to achieve optimized radiation protection for both atomic radiation workers, persons who, because of employment in connection with a nuclear facility, may be exposed to radiation in excess of 0.1 of the dose limit for occupational exposures, and for persons other than atomic radiation workers, in particular members of the public living in the vicinity of a nuclear facility. Radiation protection must be considered during the siting, construction and decommissioning of a facility as well as during its operation. This requires a staged licensing process with AECB licences issued at each stage. In practice, each licence is a milestone in a continual process of assessments, evaluations and inspections.

The siting of a nuclear facility could have a significant effect on the level of radiation protection provided to members of the public, therefore the first stage of the licensing process is a requirement to obtain a site licence. A proponent must submit details of the plan for preparatory work for investigation of the site conditions which might affect or be affected by the nuclear facility built on the site. In the amended Regulations, there will be a requirement for a public information program at this stage.

Prior to building a nuclear facility, a proponent must obtain a construction licence. The application must contain a description of the proposed design, an assessment of the hazards that may result from the operation of the nuclear facility and a description of the measures to be taken to prevent or minimize such hazards. The requirement for AECB approval at the construction stage ensures regulatory input into the design of features which affect radiation protection.

At the end of the construction stage, the proponent must obtain an operating licence which specifies the conditions under which the facility may operate. The proponent must submit a detailed description of the facility as constructed, a detailed outline of the process, operating policies and principles, and radiation protection program. Before an operating licence is issued, the proponent must convince the AECB that he is capable of operating the facility in compliance with the regulatory requirements.

Before closing down an operation, a licensee must obtain a decommissioning licence. The proponent must show that the radioactive waste remaining in the waste management part of a facility will be contained and that radiation doses to the public resulting from this waste will be below legal limits and as low as reasonably achievable.

PRINCIPLES OF RADIATION PROTECTION

The AECB follows, to a large extent, the recommendations of the International Commission on Radiological Protection. (7) The main principles of the ICRP are:

a) justification: no practice involving radiation exposure shall be adopted unless its introduction produces a positive net benefit;

b) optimization: all exposures shall be kept as low as reasonably achievable, taking into account relevant social and economic factors (the ALARA principle);

c) individual dose limits: dose to individuals shall be limited in order that detrimental, non-stochastic effects are avoided and stochastic effects are limited to a level deemed acceptable.

"Justification" for a practice, such as generating electricity with nuclear power, is a societal decision. The AECB's role in this process is to determine how safe is "safe enough."

THE ICRP RECOMMENDATIONS AND THE CANADIAN APPROACH TO REGULATION

In general the radiation protection aspects of the Canadian Atomic Energy Control Regulations reflect the recommendations of the ICRP. Any deviations from the ICRP recommendations in both the current regulations and in the proposed amendments are based on extensive AECB experience in all aspects of the regulation of the nuclear fuel cycle. Following are some examples of the ways in which the AECB has viewed the ICRP recommendations.

ALARA

It is recommended in ICRP Publication 26 that "all exposures shall be kept as low as reasonably achievable, economic and social factors being taken into account". The current regulations do not specify an ALARA requirement, but the principle is applied in the licensing process. A requirement for ALARA is proposed for the general amendments to the AEC Regulations. A detailed set of ALARA requirements will not be included in the Regulations, although it is recognized that the AECB will have to provide additional guidance on the implementation of ALARA. Since the ALARA concept involves social and economic considerations, implementation will be continued through the licensing process. The social and economic factors that must be considered include the cost of reducing doses from a given level to a lower level, and possible loss of employment if doses must be reduced to such low levels that an operation must be discontinued. In practice however "experience and judgement" might be a more appropriate phrase to use than "social and economic factors" in the statement of ALARA. The AECB has not and probably will not adopt an alpha value for optimization. ALARA considerations must also provide a balance of individual vs. collective doses and occupational vs. public doses. For example, if occupational exposures to radon daughters are reduced by increasing mine ventilation, the cost must be estimated, not only in terms of dollars, but also in terms of collective dose to members of the public.

It should be emphasized that while inclusion of ALARA in a regulation is new, its practical implementation is not. For example, uranium milling, refining and fuel fabrication facilities have been subjected to a concerted effort since the early 1970s to reduce worker exposures in the most cost-effective manner possible. As a result of these efforts, maximum uptakes have been reduced by a factor of 4, and average uptakes have been reduced significantly. Experience is an important factor in the implementation of ALARA and operational limits and targets have been set by licensees in all parts of the nuclear fuel cycle. Codes of Practice for mining facilities are another example of the implementation of ALARA on a site by site basis.

Individual Dose Limits

Dose limits for both atomic radiation workers and persons other than atomic radiation workers are specified in the Regulations. Where it is impracticable to measure the dose directly, e.g. following the intake of some radionuclides, dose can be estimated from the ratio of the estimated intake (as determined by some means such as air concentration and occupancy time) to the limit on intake. The Annual Limit on Intake is a secondary limit defined as the intake in any year of a radionuclide which will result in a committed dose (the dose that will be received during the next 50 years following the intake) equal to the dose limit.

Many limits can be derived from the basic dose limits for operational purposes. These include the derived air concentration, the average concentration in air of a respirable radionuclide to which workers would have to be exposed during a year in order to receive an annual limit on intake of the radionuclide. Another derived limit is the derived emission limit (DEL), a limit at which release of a radionuclide would not result in a dose to a non atomic radiation worker exceeding the dose limits set by the AECB. These limits are derived from the primary dose limits and models of radionuclide transport pathways. The submission of DELs and their approval by AECB staff has been part of the licensing process for nuclear generating stations for many years. To maintain consistency in its regulatory approach, the AECB has recently required that DELs be calculated for the refineries and is considering their use at uranium mining and milling facilities.

The current Regulations specify that when determining the dose, contributions from external sources and from sources of radiation inside the body must both be included but do not specify how this is to be done. The method, viz. using the ICRP concept of effective dose, will be included in the amended Regulations.

The effective dose concept was recommended in ICRP Publication 26 to ensure that the limit on stochastic risk to an individual is the same whether the whole body is irradiated uniformly or non-uniformly. This is done by using weighting factors, representing the proportion of stochastic risk from irradiated tissues to the total risk, when the whole body is irradiated uniformly. In the amended Regulations it will be specified that the dose limits apply to the sum of the dose resulting from external exposure during one year and the committed dose, the dose that will be received during the next 50 years, from that year's intake of radionuclides.

For workers at power reactors of the CANDU-PHW type, external exposure and tritium uptake account for most doses. Tritium is uniformly distributed throughout the body and results in a whole body dose. The implications of ICRP 26 would not be very significant because most of the committed dose from tritium is received within a few weeks. It is current practice to combine the internal dose from tritium with the external dose to estimate the whole body exposure for a given year.

The addition of dose from external sources and from internal exposures is not so simple at the front end of the fuel cycle. Uranium, thorium and their decay products have long biological half-lives and are retained in more than one organ for various lengths of time. Estimates of the committed dose utilizing urinalysis and thorax counting become exceptionally complicated because of the variability in the solubility of the uranium compounds and the size of the particles to which the workers are exposed.

Application of the effective dose concept to uranium mining has caused the most controversy. Further restrictions on certain operations might be required where significant combinations of exposures to radon daughters, gamma radiation, long-lived dust and thoron daughters could approach the regulatory limit. On the other hand, change from the current regulatory limit of 4.0 WLM a^{-1} to 4.7 WLM a^{-1}, as recommended in ICRP 32 (8), is perceived by workers and others as a relaxation of protection, even though the 4.7 WLM limit will be applied within the framework of effective dose while the current limit applies to radon daughters alone.

The use of Annual Limit on Intake to estimate doses from internal sources is perceived by some licensees to be very restrictive, since the entire committed dose must be applied to the year of intake. In the past, some workers in fuel fabrication plants have received intakes of uranium and hence committed lung doses which if assigned in the year of intake would have been greater than the annual dose limit although the dose received in any year has generally been less than the dose limit. This may be less of a problem in the future since licensees have been striving to reduce exposures, and hence intakes, in keeping with the ALARA principle.

Monitoring Requirements

The ICRP defines two conditions of work: working condition A, where annual exposures might result in a dose exceeding 0.3 of the dose limits and working condition B, where it is unlikely that the annual dose will exceed 0.3 of the limit. Individual monitoring is recommended for workers in Working Condition A, but is not considered necessary for workers in Working Condition B, although it may be carried out on occasion to confirm that conditions remain satisfactory.

In Canada, we do not apply the Working Condition concept. Workers are either considered to be ARWs, in which case individual monitoring is required where feasible, or not to be ARWs, in which case individual monitoring may not be required, although some form of monitoring may be required to ensure that conditions do not change such that the workers should be classified as ARWs.

Certain technical specifications must be met in order to comply with the regulatory requirement to determine dose. Both technical and quality assurance requirements will be clearly specified in the AECB document "Guidelines for the Approval of Dosimetry Programs Used by Licensees of the Atomic Energy Control Board" (9).

Female ARWs

The 1960 AEC Regulations did not contain exposure restrictions for women of reproductive capacity but specifically prohibited pregnant women from being atomic radiation workers (ARWs). Amendments (1974) based on the recommendations of ICRP 6 provided for protection of the foetus through a limit on occupational exposure of 2 mSv per two weeks, to the abdomen of women of reproductive capacity and a maximum of 10 mSv received at an even rate over the remainder of the pregnancy, for a pregnant woman.

The special dose rate restrictions for women had the undesirable consequence of effectively denying employment to women in some positions that involve an occupational exposure to radiation. The Canadian Human Rights Commission consequently asked the AECB to review the situation. The AECB referred the question to its medical advisers and to the Advisory Committee on Radiological Protection. The outcome was an amendment to the AEC Regulations in 1985 (10) which, in the interests of employment equity, eliminated any special limits for women of reproductive capacity except when pregnant. However, this amendment imposed the requirement that female ARWs inform their employers immediately after they know they are pregnant. Once the worker has informed her employer, a maximum rate of dose accumulation and a maximum allowable dose during the remainder of the pregnancy are specified.

Quarterly Dose Limits

The current AEC Regulations contain dose and exposure quarterly limits for ARWs. Although they are no longer recommended by the ICRP, it is intended to retain them as an aid in ensuring compliance with annual limits when the regulations are amended. Further, explicit limits for women of reproductive capacity have been eliminated to ensure equal opportunities for employment. Nevertheless, there is still a need to protect an embryo or foetus prior to the pregnancy being known. Quarterly limits provide some control over the rate at which the dose can be received and therefore protect the unborn child in the early stages of pregnancy.

Quality Factor

It is recommended in ICRP 26 that a quality factor of 20 be used for alpha particles. The AECB has incorporated this value into the proposed Amendments to the Regulations. The ICRP also recommended a quality factor of 20 for high energy neutrons at its 1985 Paris meeting. (11) The AECB subsequently supported a research project to

review the literature and the Canadian situation. It was concluded that any revision to the neutron quality factor could await completion of studies that are still ongoing, including the ICRP's evaluation of recent data on risk estimates which will occur during the review of its recommendations that is to be undertaken over the next few years.

Public Dose Limits

In its statement from the 1985 Paris meeting (11), the ICRP recommended an effective dose limit of 1 mSv per year for members of the public. However, it was noted that it is permissible to use a subsidiary limit of 5 mSv per year for some years, provided that the average annual effective dose over a lifetime does not exceed the principal limit of 1 mSv in a year. Since this is virtually impossible to put into a regulation and since doses to members of the public are already well below the proposed 1 mSv limit, it was decided that while reduction of the dose limit would have a substantial cost, little benefit would be gained. A further consideration was the fact that there are some occupationally exposed workers who may regularly receive annual doses in excess of 1 mSv, but less than 5 mSv, who are not currently classed as atomic radiation workers. The number of such workers is unknown but thought to be a few thousand. These include nuclear medicine technicians and university researchers. In these cases, changing the dose limit would result in such workers being classed as ARWs. They would possibly benefit to some extent by being provided with individual monitoring and perhaps increased medical surveillance. However, these potential benefits do not appear to be sufficient to justify the overall impact resulting from an overall reduction in the dose limit. As a result, the annual limit will remain at 5 mSv in the amended Regulations.

OTHER REGULATORY CONSIDERATIONS

Risk Factors

A report issued from the Radiation Effects Research Foundation (12) in which radiation doses were recalculated for the Hiroshima and Nagasaki bomb victims has led to the speculation of the need to reassess the dose limits. Better estimates of the shielding effects of the buildings, etc. during the bomb explosions indicated that radiation doses were 20 to 30% less than had been estimated in 1965. This means that risk factors may need to be increased proportionally.

In addition to the above, more cancer cases are being seen as the follow-up period since 1945 increases. In general, these are appearing in people who were children in 1945. If this factor is added to the dosimetry factor an overall increase in risk of a factor of the order of 2 can be calculated. However, it must be remembered that this may not apply to occupational exposures since the latter are received by adults, not children.

The ICRP issued a statement following its 1987 meeting in Como (13) in which it noted that although upward revision of the risk coefficients seems likely there is no need to do this before a comprehensive analysis of the sources of epidemiological information is completed. This is expected in 1990. The Commission points out that average occupational radiation doses are in most cases far below the limits and that the limits are not the controlling factor. ALARA or the optimization principle is considered to be responsible for the current low average doses. This was acknowledged in ICRP-26 and ALARA was the main recommendation of this document with respect to control of occupational and public dose limits.

Requirement to Inform Workers of Risk

The amended AEC Regulations will contain a requirement for employers to inform their employees who are atomic radiation workers of radiological risks associated with their work. A guideline listing how this should be done, a training guideline and an information document on risks associated with radiation are being prepared by the AECB to help employers meet this requirement.

FUTURE TRENDS

There is evidence that when international agencies such as UNSCEAR and ICRP complete their re-evaluation of the multitude of parameters used to determine risk coefficients and to set dose limits, the result will be a recommendation to lower the limits for stochastic effects. Much, but not all, of the evidence comes from follow-up studies of the survivors of the atomic bombings of Hiroshima and Nagasaki. A reassessment of the bomb dosimetry was published in 1987 by the Radiation Effects Research Foundation (12). However, the work is ongoing and further refinement of the dosimetry models for stochastic effects may be forthcoming. Studies on non-stochastic effects, such as mental retardation, are also ongoing. It is noteworthy that no measurable genetic effects have been recorded to date.

In anticipation of higher risk estimates, the National Radiological Protection Board of Great Britain has already recommended (14) that occupational exposures be controlled so that the average annual effective dose of a group of workers does not exceed 15 mSv and that effluents discharged from nuclear installations be controlled so that doses to members of a critical group do not exceed 0.5 mSv per year per site. Because nuclear facilities are already operating according to the ALARA principle, the impact of such recommendations will be minimal. Note that the recommendation does not refer to lowering the dose limits, but such could be inferred. As previously stated, the AECB does not see a need to lower dose limits before all the evidence is considered. (15) However, it is necessary to be aware of the likelihood that some countries could lower their dose limits in the 1990s.

Another point to consider is the practice of comparing radiological risk with other occupational risks in safe industries. As these industries become safer, our reference point will change and the "acceptable" levels of radiological

risk may also be reduced.

Considering conventional and radiological risk as components of the overall risk from nuclear facilities and subjecting both to optimization also warrants future attention.

CONCLUSIONS

The majority of the recommendations of international bodies, such as the ICRP, are incorporated in the current AEC Regulations and in the proposed General Amendments. Where Canadian experience has indicated a need for deviation from the ICRP recommendations, the AECB has made such changes. For example, quarterly dose limits have been retained in the AEC Regulations.

The AECB feels that as long as nuclear facilities are constructed, operated and decommissioned according to the ALARA principle, the health and safety of Canadians will be maintained. Dose limits may indeed be lowered in the future, but it is unlikely that this will affect the dose received, and therefore the risk to any individual because the actual doses are already well below the limits.

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Speakers' Corner

Victims of the nuclear debate

Ray Silver

An adaptation of a talk given to the Deep River Science Association, November 1988.

I have been involved in the nuclear debate since 1951. That was when four Chalk River boffins – Norman Alcock, Donald Brunton, Ron Maskell and Peter Stewart – set up shop in Oakville, Ontario. Their nuclear engineering firm, Canadian Isotope Products, would develop industrial applications for the powerful isotopes being produced in the NRX reactor. But first they had to convince hard-headed engineering executives and suspicious labour leaders that things called "radioisotopes" could not only do the job, but do it safely. That the fact that radioactivity was involved did not necessarily imply an atomic explosion or a range of horrible after-effects on the users. After all, selling nuclear equipment a mere six years after Hiroshima and Nagasaki was a bit like peddling laboratory rats in the wake of the bubonic plague.

They had what's nowadays called an "image problem", and that's where I came in. I was public relations manager of a Toronto-based advertising agency, and one day my boss called me in and said: "there are some chaps doing something with atoms in Oakville. Go out there and help them." It was a daunting challenge then. It still is today.

We started in 1951 with a small monthly publication – Peter Stewart ensured everything we wrote was scientifically accurate and I made sure it was understandable to the non-scientist. Together we learned to negotiate the tightrope of science reporting, avoiding falling into grossly misleading oversimplifications on one hand, and precisely accurate (but totally unintelligable) definition on the other.

Now, 38 years later, I'm still writing about the nuclear business and the nuclear debate. For the last 12 years I have done so as an independent journalist answering to no-one but the editors who handle my copy. I have no political affiliation, no clientele, no axe to grind. But I do have opinions. Specifically I have opinions on the nature of the debate, its impact on a major Canadian scientific achievement, its impact on the government process and its perhaps most serious impact, that upon ordinary people whose lives are disrupted and are, in effect, disenfranchised by the participants in that debate.

As we approach the last decade of this century I weep at the sight of myopic, gutless politicians who are selling out our world-class nuclear expertise. They betray the heritage of Rutherford at McGill, Beck at Niagara and Howe and Green at Chalk River. And for what? For tomorrow's front-page photo opportunity, a radio "sound-bite" or a 30 second TV news clip.

In October last year I submitted questions on the nuclear issue to the Ottawa headquarters of the three main political parties. The NDP refused to answer my questions – they even refused to admit they had a stack of anti-nuclear policy statements on the record.

The Conservative party opted for the *status quo*. Despite the recommendations of the Sparrow Committee to speed up nuclear disposal and to do so under AECB leadership, the Mulroney government has decided it wants a lot more public, technical, scientific and environmental review of the $300 million programme which has already proved that the crud can be safely buried in the Canadian Shield. Their review plans did not mention the AECB.

The Liberals said that their "chief nuclear energy policy priority" was the establishment of "an environmentally safe, commercial repository for high level radioactive waste" and that they would beef up the AECB in pursuit of this goal.

To a certain extent the Liberal position seems to echo the conclusions of the Sparrow Committee that nuclear wastes can be safely handled, stored, transported and disposed of "providing the political will is there" and that the AECB should be funded and authorized to get on with the job. Of course the perspective about these things can depend upon which side of the dispatch box you're resting your feet at the time the decisions should be made.

All this recent discussion about nuclear waste might lead the average member of the public to believe that the political and public relations dimensions of the problem are just now being properly identified. But this isn't the case. Some 11 years before the Sparrow Committee released its report I was one of a group of six people sitting around Federal Energy Minister Gillespie's table trying to resolve the Canada-Ontario nuclear waste hassle (I was Ontario Energy Minister James Taylor's Executive Assistant at the time). What fell out of those discussions was:

– nuclear waste disposal research had already been under way at Chalk River for 25 years

– there were no unresolved technical problems to prevent the safe burial of the waste

– the problems were political.

The following ten-year, one third of a billion dollar concept verification programme (ie stall) was a public relations exercise to get a hot potato out of the throats of the politicians – it was also a make-work boon for a number of nuclear boffins. And still politicians continue to play out a multi-million dollar farce. The current six-member siting task force with its $3.5 million budget now say it will be at least another year before they can recommend criteria for cabinet consideration. Then it should only take three to five years to actually pick a location. Don't hold your breath.

This flaccidity of the political will is bad enough and is proving costly (in strictly economic terms) to the nuclear industry and, ultimately, society as a whole. But, as I shall

demonstrate, far more serious costs are also being incurred.

That the politicians may be well-intentioned is not in dispute. However, remember with what the road to Hell is paved.

Equally well intentioned, it may be, are those organisations and individuals who oppose the application of nuclear technology. They claim to be opposed to nuclear weapons. They claim to stand on guard for public health and safety. They claim to be a force for environmental protection. But the effects of their activities seem to be precisely the opposite. By substituting dogma and rhetoric for reasoned discourse and systematic analysis they wind back the intellectual clock to a pre-Baconian era. This is very dangerous for society in general and has been positively harmful to individuals.

How can this be? Perhaps the most blatant example is the case of 50 families living on McClure Crescent in Metro Toronto's Malvern community whose lives were irredeemably disrupted when self-proclaimed guardians of public health and safety, with the enthusiastic participation of the news media, transformed a non-issue into a public health emergency. Trigger expressions such as "radioactive contamination", substituting for the "unclean! unclean!" cry of the 12th century leper, were used to place citizens beyond the Pale. In the name of public peace of mind the peace of mind of fifty families was set at naught.

A pleasant suburban street with real people living on it, McClure Crescent was reduced to an abstract image. Nuclear era sleuths were pictured bent earnestly over their geiger counters. TV reporters glanced nervously over their shoulders while interviewing residents. The McClure Crescent families were depersonalized to "radiation victims" – an untouchable classification which allowed them to be dropped from the conscious concern of their elected representatives. They became depersonalized beings in a proscribed neighbourhood and as such they could be impersonally exploited by those with a vested interest in tapping the news value of radioactive garden soil.

Now, the source of this contamination was refinery debris and war-surplus luminous markers containing no more than a pinch of radium. Except for marginal hot spots, conspicuously barricaded with snow fencing, in two backyards the soil emitted no more radioactivity in 1980 than the breath and bones of a bed-mate. Back in 1945, wartime nuclear scientist Leslie Cook had measured the radiation in that area and at a downtown Toronto office building as part of an RCMP investigation into a $3 million fraud. Cook had urged both federal and Ontario health authorities to decontaminate the sites, but this advice was ignored.

In 1975 – a year after federal and Ontario housing authorities built homes on the site – some fogged film in the downtown building put the AECB back on the track of the wartime radiation pollution. An AECB team air-hammered, sandblasted, scoured and scarified 103 Church Street. The team back-tracked to Port Hope where they found that 400 homes needed decontamination. At the same time the AECB's decontamination chief Geoff Knight sampled McClure Crescent at 24 locations. He found nothing alarming. Nor did AECB radiation expert Roger Eaton when he examined 100 Malvern home sites nine years and several surveys later. But by then the AECB had long since decided that the soil should be removed from 50 McClure Crescent home-sites not because of its radiological danger but for psychological and political reasons.

Three things had created the psychological and political evironment making such action necessary:

– the Porter Royal Commission on Electric Power Planning in Ontario had become a national focus for the nuclear debate

– politicians at all levels and of all parties succumbed to the NIMBY (Not In My Back Yard) disease

– anti-nuclear activists and environmental lawyers made McClure Crescent their battleground.

In the spring of 1975 when the AECB began decontamination of 103 Church Street and made a public appeal to identify those who had worked there the Toronto news media showed little interest. For one thing the AECB people talked about the old, familiar, cancer-treating radium. They didn't use trigger words like "nuclear" or "atomic radiation." For another, the Porter Royal Commission had not yet started. But by the time the Toronto building was decontaminated and a federal-provincial task force had identified 109 other radium polluted properties across Canada the Porter Commission was running a media circus.

Chairman Arthur Porter's mandate was to ventilate public concerns about Ontario Hydro's environmental and socio-economic impact. But you don't give the audience Shakespeare when they want a skin show. The Commission shuffled most of the dull weighty issues over to the legislators. With the media and a mass audience clamouring to be entertained, Porter discovered that atomic radiation would send fascinating shivers down public backs and that "nuclear" was a seven letter word with a sexy ring in Canadian news-rooms. For five years Arthur Porter played impressario to the nuclear debate. Attracted by $346,000 in research funding and witness fees, self-proclaimed public interest groups, activists, pseudo-scientists, environmental lawyers and miscellaneous hucksters came pouring out of the woodwork. And they were in full cry when the contaminated soil was rediscovered on McClure Crescent.

Within a year of the Porter Commission's inception Geoff Knight noted its impact.

> *Due to considerable publicity, the AECB is finding that decisions and choices are subject to political pressures and that reasonable technical and economic information is no longer sufficient. The AECB and other regulatory agencies now find that they are facing problems which, with the publicity given to these 'discoveries' all cry at once for immediate solution.*

"Radioactive traces found in two Scarborough backyards" said a 20 November 1980 headline in the *Globe and Mail.* Within a week the AECB invited Malvern householders to a public meeting. Roger Eaton assured them that the hot spots would be removed. Scarborough's MOH said he was not "unduly worried about radiation equivalent to two Mickey-Mouse watch dials." A local alderman, with a graduate degree in nuclear physics, did not think the problem was serious. But Scarborough mayor Gus Harris would have none of this: get that radioactive soil out of Scarborough, he demanded.

As the controversy heated up AECB president Jon Jennekens was getting increasingly concerned about the plight of

the local families. "The amount of radium in the soil was very small, but it had become a matter of mental anguish for the families there." he would recall.

If we could have taken the soil to the Madawaska Mine site near Bancroft it would have promoted vegetation to contain the mine tailings. We outlined the options in a news release and discussed them with our Ontario colleagues. We talked to the Madawaska Mine people and they were happy to cooperate. We met the local township officials who accepted our assurances that there would be no environmental contamination.

So far, so good. Then Bancroft Council held a public meeting. It was here that the mild-mannered, scientifically-oriented, rational-minded AECB chief first confronted nuclear madness. Years after the event he still spoke of the meeting with astonishment:

About 150 people attended; some were there for an argument. They were there to say 'not in my backyard. I don't care how sound your technical arguments are.' At that point the Ontario government decided they didn't want any part of a controversial plan. If they had supported us the Malvern problem would have been removed in the summer of 1981. If we had stood up to the two levels of government and said 'Throw out these nonsensical arguments; throw out all these confrontational tactics' it would have been inescapable that this was the way to go.

Unfortunately the AECB capitulated. Again a temporary storage location in Scarborough was sought and again Mayor Harris said "I won't have any of this; don't bother me with arguments."

Next the AECB proposed temporary storage of the soil on an asphalt pad in a remote corner of Camp Borden. This armed forces base, with its civilian population of 8000, was organised by the Public Service Alliance of Canada. As the Alliance's regional representative Arthur Curtis told me "I don't think the federal liberals or the provincial conservatives are clean on this whole thing. Borden was selected purely for political needs."

Politics were certainly involved and the NIMBY factor took a quantum leap. "Our governments have agreed that the low-level radioactive waste in McClure Crescent area must be removed", Premier Davis reminded Prime Minister Trudeau, "instead of the current plan to move it to Camp Borden, it is in the public interest that it be removed to the AECL waste disposal site at Chalk River." Sean Conway, Liberal MPP for the Chalk River region, held a different view: "It is offensive to me that you feel the Upper Ottawa Valley ought to become the province's nuclear waste disposal site" he told the premier. Perrin Beatty, a Borden area conservative MP, saw liberal chicanery at work – "it was a decision made strictly on a political basis to get it out of Scarborough where it was creating problems for federal works Minister Paul Cosgrove" he said.

Essa Township reeve Charles Pridham, who owned five tourist park sites, an arena and 28 acres alongside Camp Borden, claimed residents were worried about their health and property values. With such concerns the Public Service Alliance sent Arthur Curtis to Borden. After discussions with Perrin Beatty and Charles Pridham "we decided to hold another demonstration." Beatty was worried about both the radiation hazard and politics. In any case he didn't trust the AECB. "The only way people will be satisfied with their safety is if there is a full, public environmental assessment hearing by a disinterested third party" Beatty insisted. He thought there should be input from such nuclear waste experts as the Canadian Environmental Law Association and Energy Probe.

In the summer of 1981 Beatty feared that Borden base residents were being muzzled by military authority. So he transported demonstrators to Toronto to picket the Ontario Legislature. It was a Sunday, with nobody around – nobody, that is, except the news media. Men women and children were paraded before the newspaper and TV cameras waving home-made signs such as "Save us kids, you'll need our taxes." There was no mention of the children on McClure Crescent.

Three days after the Queens Park demonstration Mr Justice Mahoney dismissed bids to stop storage of McClure Crescent soil at Borden. A month later Appeal Court Justice Pratte reversed Mahoney's ruling. He doubted that the Government of Canada could authorize the AECB to remove contaminated soil from private property regardless of how much or how little radioactivity it emitted. Already fed up with the nuclear waste controversy, Energy Minister Marc Lalonde called off the government lawyers. Lalonde effectively took the Atomic Energy Control Board out of the decontamination business. No subsequent government – liberal or conservative has had the courage to reestablish the AECB's authority for decontamination in Canada – either in the courts or in the House of Commons.

What is truly frightening about all this nonsense is not that it demonstrates how easily people can jump at shadows but how readily citizens' welfare is set at naught when rhetoric, dogma and deliberately exploited irrational fears are allowed to dominate the way our society operates. The phenomenon is not new – the witch hunting of the Middle Ages is a good example of it – but surely our society has progressed a bit since the Middle Ages.

My comments on the various groups and individuals who were active in such affairs might seem extreme, but surely if one objectively reviews the shameless fashion in which the residents of McClure Crescent were exploited and the mental anguish to which they were subjected then extreme terms seem demanded.

Consider, for example, the involvement of Sister Rosalie Bertell, a Jesuit nun whose expertise is analyzing epidemilogical statistics for others to use in cancer research. Early in the McClure Crescent affair she volunteered to assist a lawyer acting for four families by arranging to have their children tested. Her demands for urinalysis and blood tests created half a dozen front-page stories in Toronto papers in mid-1981, but health authorities opted for whole body scans at Toronto General Hospital. When no trace of abnormal radiation was found Bertell, and her associate Harri Sharma, insisted the scanning was inadequate. They convinced at least one distraught father of their views who, in turn enlisted his neighbours' cooperation to have 41 children provide urine and blood samples. A *Globe and Mail* headline summed up the result: "Malvern children found healthy but parents worried over A-soil", a not surprising response.

But neither Bertell nor Sharma were reassured. They said the summer-long testing was "inconclusive" and insisted that more urinalysis should be done. Then Sister Bertell cited blood counts to spark a front page *Toronto Star* story that "Kids in radioactive area have low white cell count". That was too much for a physician formerly associated with Bertell and Sharma. The results were as likely due to a virus as to radiation, he said. "Nevertheless," said the *Star*, "Sister Bertell finds the results disturbing because of the residents' close proximity to radiation".

The following summer Sister Bertell revealed even more disturbing news. One McClure Crescent child had a lead level suggesting exposure to more than 40 times the radiation considered safe by the AECB. "Child's level found 46 times average" said a *Globe and Mail* headline. "Child's high lead level blamed on McClure soil" said the *Star*. This startling report, cited only by Bertell and Sharma, dropped into obscurity as quickly as it was raised. Puzzled that this dramatic finding was never mentioned in the course of two years of litigation by McClure residents, I queried Sister Bertell.

Had her study ever been reported in a scientific or medical journal where it would be subject to peer review? Well no, it hadn't.

Could I see a copy of her data? Well, no. "Nothing has been written up. I've done all this free of charge in my spare time."

Rosalie Bertell epitomizes the anti-nuclear activist. She is uninhibited by any professional affiliation or the restraints of an academic discipline. Her notes are unavailable. Her research is not subject to peer review or available for confirmation. She is not to be read in international science journals, instead she issues press releases to news media which never question her authenticity, credibility or area of expertise. Without reservation they report her pronouncements on nuclear science, radiation medicine, radioactive pollution, decontamination engineering, human health and physiology. Jurists have disqualified her evidence as well-intentioned but beyond her expertise. But the news media adore her. She can always be relied upon for newsworthy comment and she photographs benignly.

Much has been written about the nature of the nuclear debate. It is characterized by the glutinous vocabulary of intellectual appeasement, a debased rhetoric and warped and rigid dogma. In itself that would be bad enough. But the fact that it has real victims who suffer real harm – like the residents of McClure Crescent – makes its current form unacceptable.

Ray Silver is Canada's best known and best informed journalist covering nuclear and general energy topics. He has been associated with the Canadian nuclear enterprise virtually since its inception and is the author of ***Fallout From Chernobyl****. He has completed a second book,* ***The Bombmaker Scam****.*

CNS Branch News

Toronto Branch

Energy minister gives new directions

Ontario Energy Minister Robert Wong had a large and attentive audience at the Toronto Branch's February 16 meeting when he delivered his speech "Managing the present – planning the future". In view of the locale of the meeting – about two hundred yards from the downtown Toronto headquarters of a well-known public utility – it is unsurprising that the majority of the estimated 150-strong audience were from Ontario Hydro. (We were too polite to ask how many were CNS members.) And naturally enough Mr Wong addressed his topic principally from the Ontario context which is appropriate since Ontario remains the principal stakeholder in the Canadian nuclear power game.

As can be seen from the full text of Mr Wong's speech (page 10), more interactive provincial government involvement in the planning process, more emphasis on demand management, a vote of confidence in Ontario Hydro's nuclear programme and the future promise of fusion energy were his four principal points.

Of these four the first received the greatest emphasis. Leaving the audience in no doubt about his government's intention to become more directly involved, Mr Wong outlined government's role in the electricity business in Ontario, reviewed how this role has evolved in the past and explained the rationale for a closer government-Ontario Hydro relationship.

As Mr Wong noted, Hydro was a "government agency" and while the fundamental concept of an "arm's length" relationship between government and Hydro was a sound one, "early reviews and independent criticism had seen the need for effective government direction of Hydro affairs". As a result amendments to the Power Corporation Act and a new Memorandum of Understanding between Hydro and government had been prepared to ensure that "Hydro is still at arms length from government, but the arms are a bit shorter". In effect, Mr Wong explained, this meant that "if the government issues a policy statement to the utility then Hydro will do its best, leave no stone unturned, to meet the government policy. Government also has the authority to require Hydro to submit its plans and reports for review".

Central to Mr Wong's argument was that a closer relationship between Hydro and government was essential if government was to properly discharge its responsibility to steer Ontario's energy future in the right direction. But what was the right direction? While the early development of Ontario's electricity system had been characterized by supply development, Mr Wong noted, we had now reached a point where energy consumption cannot be allowed to rise out of control.

With environmental concerns risen to the fore, Mr Wong

emphasized that in the future considerably more emphasis was to be placed upon demand management and energy efficiency programmes. Such an approach, he argued, was not only the intelligent pathway toward sustainable economic growth but was also essential if we were to continue to compete with other countries in the international marketplace.

Commending the success of the CANDU reactor system, Mr Wong drew attention to Professor Hare's positive safety review and was careful to note that CANDU nuclear electricity remained one of Ontario's options for large capacity. For the future he called for "better alternatives" than those which "we must choose from right now", identifying fusion energy as a resource which offered the potential for sustainable energy development together with a relatively low environmental impact.

In the course of the lively question period, Mr Wong reiterated his conviction that the first priority in meeting future energy needs must be energy efficiency and conservation because of the "instant effect" of such measures. As well he laid emphasis on the need for increased private sector involvement in smaller scale projects because of that sector's ability to respond swiftly. Swift response with smaller scale projects, he pointed out, would give the whole electricity system greater flexibility. Addressing the question of the standards required of the private sector, Mr Wong was unequivocal in his view that private generation projects would have to meet the same environmental quality and reliability standards as Ontario Hydro.

In response to the concern that Ontario Hydro might become unduly politicized Mr Wong explained that the objective of closer government involvement was to ensure that public concerns were adequately addressed by the utility and that there was adequate input from the public and special interest groups in the energy planning process. As well, he noted, it was necessary for government and the public to become as well informed as possible and the closer relationship would facilitate this. Up till now, he said, the only document formally required from Ontario Hydro was the annual report. In the future, because of the more extensive information requirements made of Ontario Hydro there would be wider and better understanding of the utility's long-range strategy, annual operation plans and system development plans.

While Mr Wong agreed that over the last five years electricity consumption in Ontario had risen at an annual rate of 5 to 6 percent (a somewhat higher rate than had been forecast) he did not agree that the time was nearly past for beginning a new, large scale generating project. He noted that the long-range growth forecast was of the order of 2.7 to 3 percent and that prompt implementation of demand management and conservation options could "buy a bit more time". The government would, he pointed out, be making a decision over the next two years and, in the meantime "we are monitoring the situation". Mr Wong suggested that there was a tendency to underestimate the impact of the demand side of the energy equation and pointed out that the 5500 MW (including 1000 MW of cogeneration) Ontario Hydro had estimated as being available through conservation/demand management by the year 2000 might be on the low side – "we said we felt these numbers can be higher". The real figure could be double or triple this, he suggested, and pointed out that the government had asked the utility to "look at the figure" again.

Addressing specifically nuclear energy issues, Mr Wong expressed himself particularly impressed with the potential of Atomic Energy of Canada Ltd's SLOWPOKE reactor for district and institutional heating. His Ministry, he said, would make sure that the various communities and organisations operating large buildings or complexes were made aware of the possibilities of the reactor, adding "we think it's a good idea". On the question of construction of nuclear power plants specifically for power export Mr Wong explained that no formal policy existed. Though he did not appear to absolutely reject the concept he didn't endorse it either. Mr Wong was particularly enthusiastic about export possibilities for the CANDU-3 pointing to a signed agreement for a feasibility study of the construction of two CANDU-3 units (435 MW each) for China and remarked that the Chinese had expressed the view that the Canadians were insufficiently aggressive in marketing the CANDU technology.

Conferences and Meetings

Fifteenth Annual Simulation Symposium
Sponsored by CNS (NSED), to be held **May 1-2, 1989** in Mississauga, Ontario. Contact: **B. Rouben,** AECL, (416) 823-9040 or **J. Marczak,** (416) 592-7622.

International Symposium on Fission Product Transport
Sponsored by the International Centre for Heat and Mass Transfer and the IAEA, to be held **May 22-26,** in Dubrovnik, Yugoslavia. Contact: **Prof. J.T. Rogers,** Carleton University, Ottawa, Ont. K1S 5B6, (613) 564-7153.

CNA/CNS Annual Meeting
To be held **June 4-7, 1989** in Ottawa. Contact: **P. Fehrenbach,** AECL/CRNL, (613) 584-3311; **T. Jamieson,** (613) 236-3920.

5th International Conference on Emerging Nuclear Energy Systems
Sponsored by ANS/ENS/CNS, to be held **July, 1989** in Karlsruhe, Germany. Contact: **A. A. Harms,** McMaster University, (416) 525-9140.

World Energy Conference: Energy for Tomorrow
To be held **Sept. 18-23, 1989** in Montreal. Contact: **TPC,** (514) 878-3124.

IAEA Seminar on Research Reactors
Sponsored by the IAEA, to be held **Sept., 1989** in Chalk River, Ont. Contact: **P. Simpson,** AECL/CRNL.

International Symposium on Quality in Nuclear Power Plant Operation
An international symposium in cooperation with the IAEA, to be held **Sept. 10-14, 1989** in Toronto, Ontario. Contact: **D.J. Bartle,** CANATOM Inc., (416) 366-9421.

Second International Conference on CANDU Fuel
Sponsored by the Canadian Nuclear Society and co-sponsored by the American Nuclear Society the Second International Conference on CANDU Fuel will be held **1-5 October 1989** at Chalk River, Ontario. Contact: **Dr I J Hastings,** Chalk River Nuclear Laboratories, Chalk River, Ontario K0J 1J0, (613) 584-3311.

4th International Topical Meeting on Nuclear Reactor Thermal Hydraulics
Sponsored by KFK/ENS/ANS, to be held **Oct. 10-13, 1989** in Karlsruhe, Federal Republic of Germany. Contact: **W. Midvidy,** Ontario Hydro, (416) 592-5543.

International Waste Management Conference
Sponsored by ASME/ANS/CNS, to be held **Oct. 23-28, 1989** in Kyoto, Japan. Contact: **R. Kohout,** Ontario Hydro, (416) 592-5384.

Specialist Meeting on "Leak-Before-Break"
Sponsored by CNS/OECD/NEA, to be held **Oct. 25-27, 1989** in Toronto. Contact: **L. Simpson,** AECL/WNRE, (204) 753-2311.

MIT Summer Seminars
In its 1989 summer series of professional seminars the Massachusetts Institute of Technology is offering the following courses of potential interest to CNS members:

June 12–16: Modern Nodal Methods for Analyzing Light Water Reactors, Prof A F Henry (Programme 22.80s)

July 10–14: Nuclear Power Reactor Safety: Part One – Thermal Power Reactors (Programme 22.95s) Prof N C Rasmussen

July 17–21: Nuclear Power Reactor Safety: Part Two – General Safety Issues (Programme 22.96s) Prof N C Rasmussen

For further information, contact: **F J McGarry,** MIT Summer Session Office, Cambridge, MA 02139, (617) 253-2101.

Book Reviews

The jogger's dilemma

Searching for Safety, Aaron B. Wildavsky, Transaction Publishers, New Brunswick (USA) and London (UK), 1988.

Reviewed by Niels Lind

"The Jogger's dilemma" – what to do when that which promotes health is also dangerous – is the central question in this book, and perhaps also the central question of risk management in society. Aaron Wildavsky, in collaboration with D. Coyle, W. Havender, E. Nichols and D. Polisar, offers "a theory to account for the high level of safety as well as the new dangers introduced by modern technology". They give a new manifesto on "how to think about risk".

Safety has been overly identified in the past with acts intended to prevent undesirable events. To redress this, the book points to the increase in safety that can be concomitant with general progress arising from entrepreneurial activity. It is postulated that safety is secured for more people by increasing the pool of general resources (such as wealth or knowledge) than by consuming resources in an effort to protect the public against "unperceivable, hypothetical" dangers. Wealth adds to health.

This book is about how safety and risk are produced, how they are "inextricably intertwined", and what should be done to improve the efficiency and the effectiveness of the search for better combinations of safety, risk, cost and opportunity.

A philosophical stance of the book is that safety is not something that merely can be chosen at will; it must be discovered. It argues, therefore, that a strategy of trial-and-error, i.e. risk-taking, is preferable to risk aversion.

Perceived risk and subjective differences over which risk should be taken under what circumstances are in practice important in the process of selecting policy in the face of hazard. But they are dealt out of the play at the outset by observing that almost all participants in debates over risk claim a respect for facts and attempt to legitimate their preferences by reference to canons of scientific enquiry.

Wildavsky asks: What sets of axioms, principles or rules can help us discover how to reduce overall risk (the one associated with length of healthy life) so that society as a whole becomes safer? He suggests three candidates: The principle of uncertainty, the axiom of connectedness and the rule of sacrifice.

The principle of irreducible uncertainty is an assertion that "no one knows it all" and that, as we act, we are creating consequences of which we are as yet not fully aware: a modicum of uncertainty is a universal condition. Thus risk cannot be avoided. Instead, it is suggested, one must use the risky to get more of the good and less of the bad.

The axiom of connectedness states that the good (safety) and the bad (harm) are intertwined in the same option. Accordingly the search for safety is like a balancing act with evaluation and choice becoming the essence of good safety management.

The rule of sacrifice, which is perhaps the least straightforward of the three principles, states that the safety of the whole is dependent upon risk taking in the parts.

Wildavsky attributes this last idea to the economist B. Klein, who stated that a system must be able to make smooth adjustments adapting itself to new circumstances if it is to "remain predictable in the large". This does not mean that specific individuals must give up their lives or limbs for the collective entity. Rather, it means "that if the parts of the system are prevented from facing risks, the whole will become unable to adapt to new dangers". (Note, however, that individual sacrifice is precisely the dominant mode of operation in the management of two social hazards: war and violent crime.)

The book compares two rival strategies to manage the uncertainty of our collective existence, summarized in stereotype by the conservative maxim "safety first – take no chances" and the opportunistic one "nothing ventured, nothing gained". It shows by numerous instances that taking no chances is not conducive to safety; allowing no trials except with prior guarantees of no error actually increases danger by foregoing benefits. Wealth foregone is health foregone; richer is safer. One chapter documents with numerous examples the correlation of human health and economic wealth.

Another chapter asks whether it is better to try to anticipate dangers before they occur, or to strive to respond with resilience to cope with untoward events as they arise. If the anticipation of hypothetical dangers saps the system's energies without enabling it to guess right, the result is futile.

"How then can society protect itself against unknown dangers?" We can plan for prevention, but planning depends on prediction, which presumes the reduction of surprise. Minor surprise, merely a change in the system parameters, can be anticipated in planning, but it is argued that major surprise (what one might call a change of system structure) cannot be countered by planning. AIDS is a case in point; central decision makers could not imagine it before its occurrence. Confusing merely quantitative surprise with qualitative surprise (where we have no idea of the kind of event possible) trivializes the problem of unexpected danger. Wildavsky suggests that safety may be improved by spreading the task of anticipation widely throughout society: resilience through decentralized anticipation can achieve a greater degree of safety.

The two strategic alternatives, anticipation and resilience, are universal, generic strategies. Anticipation is exemplified in the verification of safety of nuclear power plants, where one safety measure is piled upon another in an attempt to ward off danger. Resilience, in contrast, is the predominant strategy of the human body; most of its efficient defenses serve to mitigate the harm as it occurs or later. These two pure strategies, possibly in appropriate mix according to circumstance, provide a richer arsenal than institutionalized anticipation alone. Indeed, reliance on anticipation alone may be unsafe; examples drawn from chemical ecology and other disciplines show that every defense system can be counteracted, every alarm

system used against the organism it is intended to protect (but does this also apply to hazards that do not involve adversaries?). Paradoxically, excessive attention to certain dangers have led to the neglect of safety, and safety measures can increase risk while courting danger may reduce it.

Safety, globally, is a function of the general resources (knowledge, wealth etc.) in a society at a given time. These resources can and do grow in time. Safety measures may consume a disproportionate amount of global resources, or even cause a decline in resources. Such measures decrease the net safety of society. Conversely, acts that are not intended to increase safety may actually do so. And the jogger's dilemma – that jogging simultaneously increases and decreases the risk of cardiac arrest – shows that safety is the other side of risk.

This book is the most important contribution to the philosophy of safety management strategy that I have come across so far. It is a cathechism for the belief in the invincibility of entrepreneurial endeavour, and a canticle for resilience as a defence strategy which a society can only neglect at its own peril. It argues inductively, with the level of rigor customary in political science; some will be convinced while others quite rationally may remain unconvinced. But safety management, such an important task in modern society, is a pragmatic business and those who practice it are free to act as if saving lives efficiently is the objective until such time as someone can suggest a better objective. This book opens the subject of global safety policy for society and makes a convincing case that resilience is a preferable general strategy in the continuing search for safety.

Niels Lind is Professor of Civil Engineering at the Institute for Risk Research, University of Waterloo.

Six impossible things before breakfast

Engineer through the Looking Glass, Eric Laithwaite, British Broadcasting Corporation, ISBN 0 563 12979 4

Reviewed by David Mosey

This excellent book should be an essential weapon in the science teacher's arsenal. And it will be an invaluable aid to the beleagured parent faced with the daunting task of helping a child select (and, oh yes, execute) the dreaded "science project". Laithwaite's book reproduces (insofar as the printed page can reproduce) six lectures to schoolchildren by Eric Laithwaite, presented under the auspices of the Royal Institute and broadcast by the BBC.

Eric Laithwaite, Professor of Heavy Electrical Engineering at Imperial College, London University is one of those very rare creatures who doesn't make science "come alive" but rather makes it explode into action. Starting from a single concept – say mirrors and symmetry – lines of enquiry flash off in all directions from the laws of electromagnetic induction, through Alan Turing's solution to the "three weighings" problem, palindromic numbers, the Möbius strip and the linear induction motor. And that's only in the first chapter. In this chapter, too, you will find how, using mirrors, to replicate Alice's problem in walking away from Looking Glass House – this makes an easy table top demonstration that requires only a few small plane mirrors and some blobs of putty to stick them in. Or you can try out the trick with mirrors where, by blowing into your finger you can make your hat fly off.

The themes are progressively expanded and developed in subsequent chapters. "Handedness" and its importance and limitations are explored, in the course of which single-phase and three-phase motors are introduced, "n" way switching is discussed and the design of a diabolical wallet that can reverse your money, or even make it disappear, is explained.

Chapter (Lecture) 4, "The Jabberwock", deals with the many "monstrous heads" of the laws of physics and shows how things can be considerably simplified by realising that the actual number of these laws is much smaller than it appears – some laws are simply "reflections" of others – and the various laws of electromagnetic induction are cited as an example. The gyroscope is introduced, and used to develop a set of analogies of the laws of electromagnetic induction. This leads to a discussion of the fallacy of the concept of perpetual motion, the gyro as a compact energy storage device, as a rate of turn indicator and as a model for the Bohr atom.

By now you should be getting the idea of the range of ideas explored in this compact little book and the absolute impossibility of trying to even list them all. There's no chapter that doesn't offer a tantalizing range of topics which can be explored even with the limited facilities of the junior school classroom – or the more even limited facilities of the kitchen table. The sixth lecture "It's my own invention" seems to bring everything together – but that's quite deceptive, for Laithwaite instead leaves his audience numberless routes for further exploration. And through his discussion of the processes of invention and discovery it is a pretty sure thing that a lot of people are going to be encouraged to start exploring those routes.

Laithwaite's own feelings about the process of discovery he sums up best in two quotations. The first is from Niels Bohr who, in discussion of a lecture by Pauli, said:

> *We are all agreed that your theory is crazy. The question which divides us is whether it is crazy enough to have a chance of being correct.*

The second is from Freeman Dyson:

> *Most of the crackpot papers which are submitted to* The Physical Review *are rejected, not because it is impossible to understand them, but because it is possible. Those which are impossible to understand are usually published.*

For a teacher or a parent, *Engineer Through the Looking Glass* will provide a goldmine of ideas that will keep any schoolchild (from, as they say, eight to eighty) absorbed and challenged. It's true that some of the demonstrations here will challenge the resources of the high school physics lab (not to mention the home) – those involving the gyroscope, for example. But even here the "toy" gyroscope, a piece of string and a firmly (emphasise firmly) mounted ceiling hook will still give you the demonstration of the Bohr atom. Yes, I tried it, and yes it works.

Elaborate apparatus is the exception rather than the rule. One of the most fascinating byways Laithwaite takes us down is the construction of flexigons. These fiendish devices (invented by Tuckerman, Feynman, Tukey and Stone) are not terribly difficult to make and are practically guaranteed to drive the user crazy trying to find the missing numbers. Even more fiendish is the hexahexaflexigon – made up of triangles of six different colours, eighteen combinations of colour and pattern should be obtainable. But only fifteen can ever be revealed. A couple of evenings with an X-acto knife, some cardboard and sticky tape will get you a perfectly serviceable hexahexaflexigon. Then all you need find is the victim...

Eric Laithwaite's concluding Chapter is a chapter rather than a lecture, since it reproduces a sample of the correspondence he received following his lecture series. This is a pleasing miscellany and includes variations on or developments of some of the problems explored in the main lectures together with a wide variety of comment, verse and anecdote. The design of a "flexicube" is presented – strictly a post-doc course for those who've graduated from Rubic's Cube, with the added twist that you actually have to make the thing yourself before you can start to do anything with it.

Perhaps the anecdotes are the most fun, and two stand out particularly. On the topic of gyroscopes one hears the sad story of what happens if you leave an 8 lb gas-bearing gyroscope spinning happily at 20,000 rpm in the lab, and pop out to the loo. What happens is your boss comes in and picks it up, that's what happens. (Oh yes, the gyro can only stand precessions of 0.3 radians/sec...)

And on the topic of inventing, our attention is drawn to the words of Sir Benjamin Baker, designer of the Forth Railway Bridge:

> *Next door to the Patents Office in Chancery Lane on one side is the Commissioner for Lunacy and on the other side is the Bankruptcy Court. Ten to one you will land in the wrong place.*

Engineer Through the Looking Glass is a vastly entertaining and tantalizing exploration of the way things work written by a brilliant, unassuming engineer who finds the world a very interesting kind of place and doesn't care who knows it.

A capital trend in regulation

Pulverized coal can be tricky stuff to handle. In an effort to improve the speed and processing capacity of my steam-driven difference engine I had procured a larger boiler and, at Bauer's suggestion, installed a pulverized coal burner. I'd set up all the gubbins in the engineering lab and was ready to go . . .

Well, as I said, pulverized coal can be tricky stuff to handle. The smoke and dust cleared pretty soon in the strong draught through the shattered windows. My ears still ringing from the detonation, I looked across the lab to see a ragged, soot-stained figure leaping across the debris towards me and uttering high-pitched screams.

It was none other than Gareth Lloyd-Thomas, Engineering Department Chairman, sometimes known as "Lloyd the latent". He came spluttering to a halt before me. "Worthing, it's you Worthing" he keened, waving a stirrup pump at me in a menacing manner, "I might have known it. I am not wanting to know what you have been doing. I am merely requesting you, as someone who is not a member of the my Department, to leaf my laporatory at once. And I respectfully submit, Professor Worthing, that your future activities, whatever they may be, should be confined to some remote location, such as an artilliary testing range, look you." He seemed a little upset.

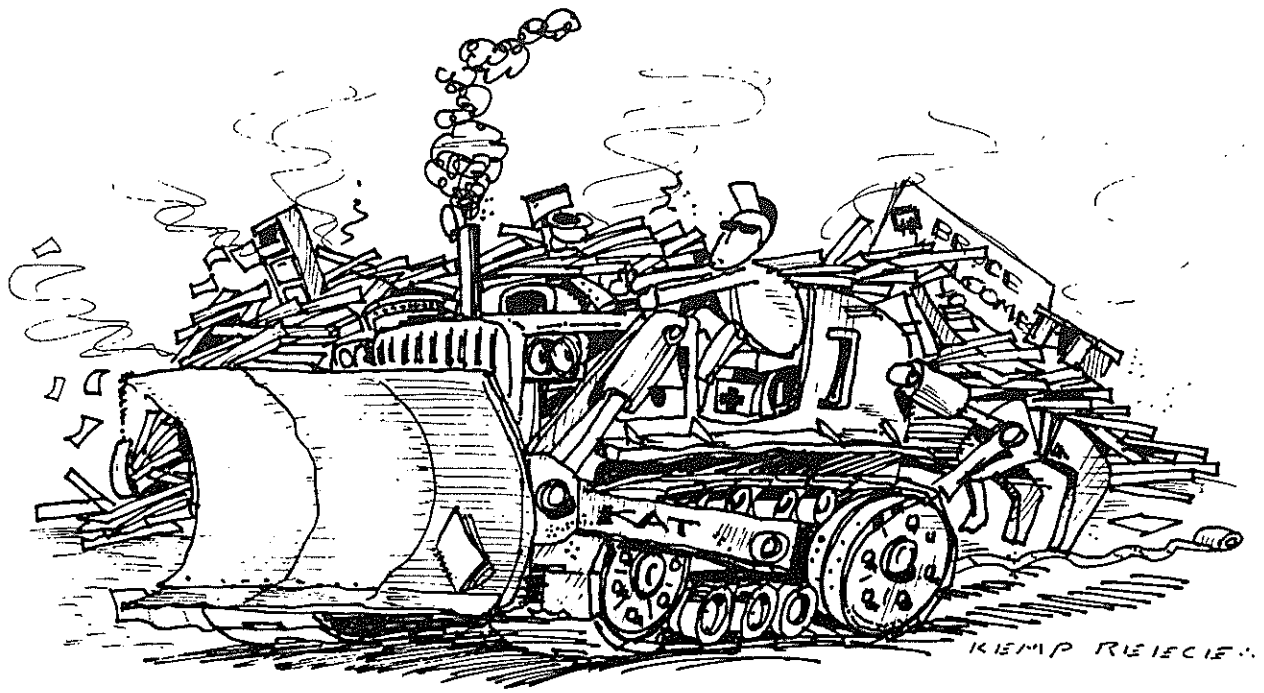
"Well, I think that most uncivil of you, Lloyd-Thomas" I protested mildly, "just because a colleague has some minor difficulties with a quite complex operation you should not descend to unseemly abuse". But he just started screaming again so I walked out with dignity.

I cut across the quadrangle, heading for the faculty club in search of a pint or so to recover my spirits. I strolled into the almost empty bar, gave my order to Brown, the lugubrious Caledonian bartender, and casually signed the chit. "Ooch, Professor Worthing" rumbled Brown, "Ye kin nae sign for yeer drinks any mair."

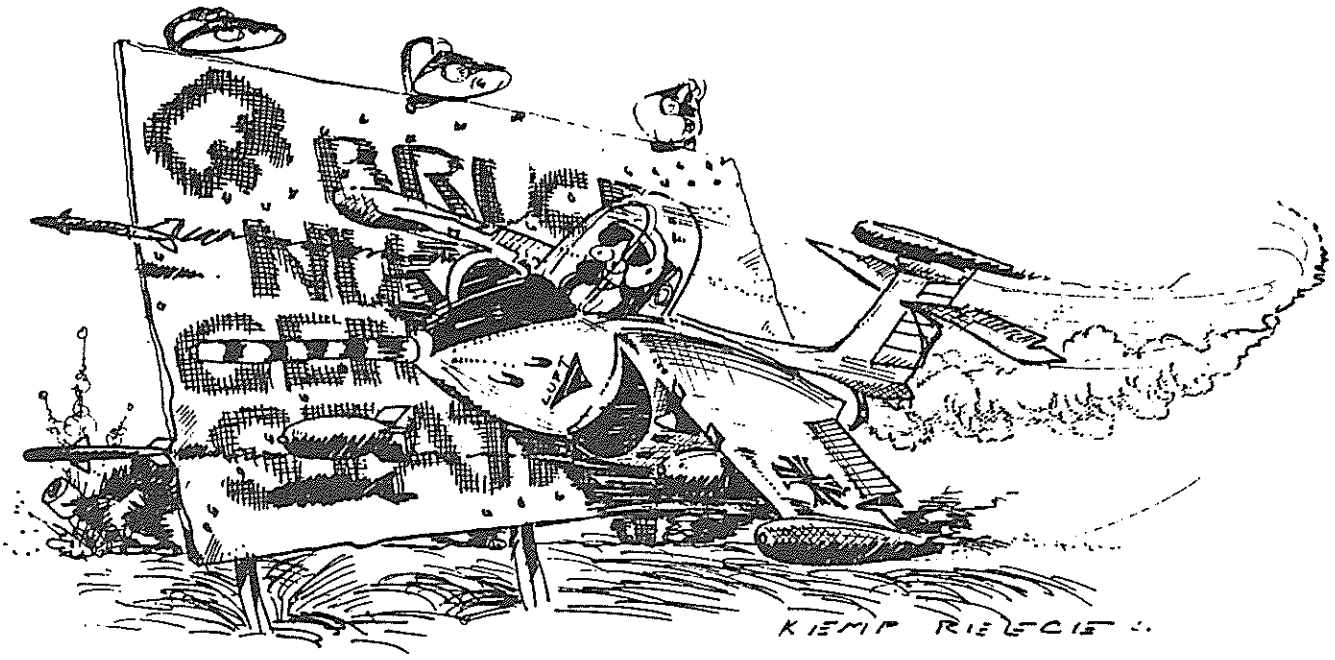
"What do you mean, Brown?" I expostulated, "you know perfectly well I'm a member in good standing."

Brown shrugged and looked entirely unapologetic. "It's the Committee, mon. Ye canna hae nae mair on account – ye mun hae the ready money".

I spent a few minutes separating a five dollar note from itself and then moodily carried my beer over to a nearby table. Things were coming to a pretty pass, I reflected, when one was asked to pay for one's drinks with ready money. I was jerked out of my depressing reverie by the appearance at my table of an elegant looking young man. "Professor Worthing?" he



. . . a fleet of wrecking vehicles arrived . . .



. . . an all-out low-level attack by NATO fighter bombers . . .

enquired. I nodded in assent. "I wonder whether I might join you? My name is Michel Blaireau – "

"Aha of course, I'd be delighted" I said enthusiastically. I knew him by reputation from Bauer's case of the Hunting of the Clochards and I had heard that he had recently joined the AECB. More importantly, he had the look of a man who is on expenses.

He confirmed my suspicions by waving for more supplies (and only just in time). He knocked back his pint with an air of enthusiasm that I could not but admire. "What brings you to Aphasia?" I asked casually. A cloud passed over his features "Problems" he responded, "problems of a nature serious and provoking. It had been my fond hope that I would find my good friend George Bauer here and seek the benefit of his advice, but alas, he is not about."

"Bauer's away till next week – Annual International Conference on Alewives" I agreed. "What's the problem?" This seemingly innocuous question unleashed a torrent of Gallic lamentation totally impossible to transcribe. However the long and the short of it was poor old Michel was having trouble with the Bruce Nuclear Generating Station. It appeared that the people there were totally ignoring all reasonable requests (not to mention the unreasonable ones) from the Board staff, "and" Michel concluded with some heat "if for once we interdict their license, those *cochons* send a *chef de quelque chose* up to Ottawa, he waves his arms and back comes the license. It is almost enough, *mon ami*, to drive a man from drink."

I was about to commiserate with him in the general (but unhelpful) manner one uses on such occasions when a faint recollection stirred at the back of my mind. I leaped to my feet. "You sit right there Michel, *vieux coq*, and I will be back shortly with information which might be of some assistance to you."

I rushed from the bar and five minutes later was in my study. It took a minute to locate the relevant volume and confirm my recollection. I returned to the bar, sat down at the table (which during my absence had miraculously sprouted more glasses – some of them full) and began my explanation.

Michel was incredulous, aghast and then jubilant and, before he left to order my plan put into effect, insisted on drinking numerous toasts to Ancient English Common Law, Perfidious Albion and (for some odd reason) the Committee for Public Safety.

Two or three weeks passed by and the matter had almost vanished from my memory when I received a visit from Bauer. He looked somewhat preoccupied. "Worthing, old chap" he began rather hesitantly, "I understand you were able to advise my old friend Michel on a regulatory problem recently?"

"Yes, quite straightforward as a matter of fact" I responded airily.

Bauer's hesitation became even more marked. "And what ... er exactly, so to speak, did you advise?"

"I simply referred him to the 1306 Proclamation prohibiting the use of sea coal, and the actions of the 1307 Commission of Enquiry in ensuring compliance" I explained, "and pointed out that these seemed to set a useful precedent".

Bauer sucked in his breath. "And what, may I ask, were these actions to ensure compliance?" he enquired in a rather over-controlled fashion.

"Oh for the first instance of non-compliance, just a fine," I explained, "and for a second, the offender's furnaces were to be demolished."

Bauer drew in another sharp breath. "That explains it" he said. "Explains what?" I asked.

"The fact that early last week a fleet of wrecking vehicles arrived at the Bruce site and have so far reduced to rubble the administration wing (including the Station Manager's office) and the Public Information Centre. Ontario Hydro is somewhat annoyed."

"Yes" I said understandingly "I can see they might be a bit cross."

"A bit cross!" Bauer exclaimed "they're hopping bloody mad. Their lawyer is writing letters like a demented traffic warden. And the Board staff are cowering in their trenches ready to push Michel over the top as a sacrificial victim!"

"Rest easy, Bauer old chap", I said easily. "Michel has nothing to worry about. This is now the moment to initiate Phase II."

Bauer coughed delicately. "I don't want to ask, Worthing, but please assure me that 'Phase II' does not include something of the nature of an all out low-level attack by NATO fighter bombers."

"*Pas du tout vieux cheval*" I said gaily, as I picked up Sidcot, brandy bottle and gasogene and headed for the door, "*pas du toute.*"

Upon my arrival at Bruce I noted with some approval the thoroughness of the destruction. The Station Manager now appeared to be conducting his business from a large tent with a field kitchen located conveniently alongside. I strolled across the duckboards and into the tent.

The Station Manager was by turns abusive, truculent, hysterical and, finally, servile. For good reason. I was short and to the point in my explanations. I obtained his signature on the document I'd prepared and left him in tears drawing little hexagons on a large sheet of paper.

Once returned to Aphasia I couriered the document to Michel. Bauer was waiting for me in the bar. "Now Worthing" he said, passing me a full pint, "what have you done? And how did you do it? Ontario Hydro and the AECB seem to have effected the most dramatic reconciliation since that of the Montagues and Capulets."

"Well Bauer" I responded, "it was simply a matter of getting the Station Manager to see things in the right perspective."

"From what I heard" said Bauer "the only perspective the Bruce Station Manager wanted to experience was that of Michel's head on a platter – with yours alongside if possible."

"Yes, but that was before I'd explained the position to him", I explained.

Bauer gave me a penetrating look. "... and the position, Worthing?"

"Well, if you'll cast your mind back to 1306..." I began.

"Yes, yes, the proclamation" said Bauer hastily.

"Right. You see, as I explained to the Station Manager, in 1306 they actually executed somebody for burning sea coal..." I let my words trail off. Bauer's face lit up.

"I see! So in the light of that, the Station Manager felt that demolition of his office was a perfectly reasonable action?"

"Yes – he was really very conciliatory. Committed himself to clearing over thirty action items by the end of the year. Michel was delighted. As was AECB. They seem to feel that a new era in the approach to regulation has arrived."

Bauer silently addressed himself to his beer for a few minutes, then turned to me, "I say, Worthing, how did they execute people in 1306?"

"I don't know", I said happily, "but I'm sure it was very nasty".

Ernest Worthing

CALL FOR PAPERS

CANADIAN NUCLEAR SOCIETY
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Papers are solicited for presentation at the conference and publication in the proceedings. Extended summaries are required first for review, and on acceptance full papers will be requested for publication in the conference proceedings.

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GENERAL INFORMATION: Summaries in English of all contributed papers will be reviewed by the Conference Paper Review Committee. The Conference Proceedings will contain the full papers of summaries accepted. Summaries should be received by Oct. 15, 1989. Authors will be notified of the status of their summaries and presentation instructions will be sent to authors of accepted summaries by Nov. 15, 1989. Absolute deadline for receipt of full papers is Feb. 15, 1990.

SUMMARY PREPARATION: Summaries should be about two single spaced pages in length including any figures and references and should contain enough detail of the paper planned for the reviewers to assess the relevance of work.

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Content: Each contributed summary must present facts that are new and significant or represent a state-of-the-art overview. The summary must contain not only the work that has been performed but also the results achieved. Proper reference should be made to all closely related information that has been published. SUMMARIES SHOULD INCLUDE AN INTRODUCTORY STATEMENT INDICATING THE PURPOSE OF THE WORK AND A CLOSING STATEMENT SUMMARIZING THE SIGNIFICANT NEW RESULTS OR BASIC CONCLUSIONS.

Word Count: The summary must be between 750 and 1,200 words, with figures or tables counting as 150 words each. There must be at least 750 words of narrative; therefore, no more than 3 figures and/or tables are allowed. References are not included in the work count, but must be limited to absolute minimum necessary (a bibliographical listing is not acceptable). Each line of an equation counts as 10 words. Limit the title to 10 words and reduce the number of authors listed to the minimum possible.

Tables and Figures: Figures and tables must be suitable for reduction to printed size of one column (width 7.50 cm). Lettering on figures must be at least 1 mm high after reduction, and the design of tables should suit the width limitation. Each table or figure must be high-quality gloss photographs or reproducible black-on-white drawings. SI units must be used in all summaries.

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