REGULATORY PRACTICES OF THE CANADIAN GOVERNMENT

WITH RESPECT TO NUCLEAR FACILITIES

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1. INTRODUCTION

When Dr. Rosen mentioned this course to a few of us from the Canadian Atomic Energy Control Board last fall, we were very pleased that a significant portion of the time was being allotted to allow you to hear and discuss the approaches to the regulation of nuclear energy taken by some of the other countries who have been involved from the early days. I think you will agree that a broad spectrum of views is essential to provide you with the information which will allow you to build up a regulatory system which best suits your needs.

Let me start by referring briefly to a topic touched on by Mr. Stadie this morning. Although the different types of reactors may influence to a small degree some aspects of regulation, the peculiar paths by which the nuclear industries have grown up in each country, the types of governments involved, their decisions at strategic points along the way, international relationships, even the temperament of the people, have all had a significant influence on the type of regulatory system currently in operation.

Let's take, for example, the U.S. and Canada. In the U.S., the law allows judicial-type public hearings to be convened by the regulatory authority relative to the licensing of each nuclear power plant, with full public disclosure of information significant to the safety and environmental assessment of that plant. In Canada, the law requires that any information passed on to the Atomic Energy Control Board in relation to the licensing of a nuclear power plant not be disclosed to the public unless the proprietor of that information gives his consent; also, the Canadian regulatory authority is not permitted to hold judicial-type hearings.

Another area of diversity is the different basic regulatory body-licensee relationship - the U.S. tend to favour a heavily-regulated industry with extensive and detailed criteria and regulations administered by a large regulatory staff, whereas the Canadian approach tends to be more one of auditing, by a proportionately much smaller staff, of a largely self-regulating industry, with the specification of broad safety principles, supplemented by licensing guides.
2. **SCOPE AND KEY PARTS OF RULES AND REGULATIONS**

In 1946, in the interests of national security and of health and safety, the Canadian Atomic Energy Control Act was passed establishing atomic energy as a Federal concern, creating the Atomic Energy Control Board (AECB), and giving it wide powers for the development and control of atomic energy.

In 1952 the Board exercised the authority given it in the Act to procure the incorporation of companies for furthering atomic energy and set up Atomic Energy of Canada Limited (AECL) to undertake research and development in atomic energy, which, at that time, meant running the Chalk River Nuclear Laboratory and proceeding with a nuclear power development program.

Initially AECL reported to the Board. In 1954 the Act was amended and from that time on AECL and AECB were independent, AECL being concerned mainly with the development of nuclear power but also undertaking research in nuclear matters, and the Board being concerned mainly with the control and regulation of atomic energy matters, although continuing to provide grants to universities for the establishment and operation of major installations in nuclear physics. The severance of AECL from AECB left the Board free to concentrate on the regulation of nuclear power without conflict of interest arising from involvement in its development.

The only other legislation specifically enacted in respect of atomic energy is the Nuclear Liability Act. This Act when brought into force later this year will place all responsibility for nuclear damage on the operator of a nuclear installation. It will require the operator to obtain insurance in the amount of $75 million (part of which may be re-insured by the government). It will also provide for the establishment of a Nuclear Damage Claims Commission to deal with claims for compensation when the government deems that a special tribunal is necessary. The Act recognizes that Canada may enter into international arrangements in respect of nuclear liability but Canada is not at present a party to any such arrangement.
These examples are in no way meant to indicate that one system is better than the other, although they obviously show my prejudiced view. Undoubtedly, if the opportunity existed, the ideal situation would be to choose the most appealing parts from each of the many systems in existence to come up with the optimum system. Hopefully, the information provided in this three-week period will allow you at least to begin this optimization procedure for your own particular situations.

I've been asked, as have the other lecturers to relate to four specific topics within the general realm of the regulatory practices of the Canadian government relative to nuclear energy, so, being a well indoctrinated regulator, I will follow the regulations.

The first section deals with the scope and key parts of the appropriate rules and regulations.
The latest revisions to the Atomic Energy Control Regulations made pursuant to the Atomic Energy Control Act came into effect last year -- in June, 1974. These regulations are more explicit about the need for, and conditions related to, the licensing of prescribed substances and nuclear facilities.

Referring to nuclear facilities in particular, the Regulations require that a licence to operate be acquired from the Board, a prerequisite of which is Board approval to construct or acquire the facility. The requirements of the application and licence conditions are also defined, as well as the records to be kept, the requirements for security and reporting occurrences, the definition of atomic radiation worker and the treatment thereof, as well as general precautions to be taken and other related topics.

Since we work closely with the provincial and other federal regulatory bodies who have an interest in health and safety, compliance with their applicable Acts and Regulations is insisted upon where they are not in conflict with the Atomic Energy Control Act and Regulations.

In general, the Board leaves the non-radiological effects of the plant, such as its sociological and non-radiological environmental impact, to be dealt with by other federal, provincial and local government departments.
3. REACTOR LICENSING ORGANIZATION AND PROCEDURES

In order for the licensing organization and procedures to make sense, it's necessary to mention our licensing philosophy.

The licensing philosophy in Canada is based on the nuclear industry accepting the major responsibility for implementing the basic safety requirements for nuclear power plants, but each of the various activities associated with a nuclear power station comes under AECB scrutiny. Those activities which are considered to be more important to safety than others are examined in depth, while other, less significant activities, are audited.

To assist in this scrutiny, the AECB established in 1956 an advisory committee (known as the Reactor Safety Advisory Committee) to advise it on all aspects of the safety of nuclear reactors. The Committee is composed of senior engineers and scientists chosen because of their individual competence, together with technical representatives of relevant federal and provincial departments and local medical officers of health. The representatives vary depending on the province in which a proposed nuclear power station is to be located. Every reactor licensed by the AECB has been the subject of an extensive review by this Committee.

With regard to the staff of the AECB itself and its role in the licensing process, we can refer to the organization chart (FIGURE 1). Officers of the Nuclear Plant Licensing Directorate carry out a detailed assessment of the design and proposed methods of construction and operation of each nuclear power station. They assist the Committee in its review, undertake inspection and compliance duties and approve design and operating procedure changes within the terms of the licences issued by the Board.

The licensing procedure is best illustrated by means of a schematic, referred to as a Licensing Milestone Schedule (FIGURE 2).
The first step taken by a utility to secure regulatory authorization to proceed with a proposed nuclear power station is the submission of an application for Site Approval (at the time of the Letter of Intent). A document known as a Site Evaluation Report must accompany the application providing sufficient information to enable the AECB, on the advice of the Reactor Safety Advisory Committee, to determine the suitability of the site proposed. The report includes a summary description of the station outlining the plant size, reactor type, basic process and safety systems as well as information regarding land use, present and future population density and distribution, principal sources and movements of water, water usage, meteorological conditions, seismology and geology.

In the past public meetings regarding the proposed location of nuclear power plants have not been held. However, licensees have had meetings with local governments and have conducted a public information program.

Because of the increasing public interest in Canada in the environmental, health and safety aspects of major projects in general and nuclear power plants in particular it is expected that some if not all utilities will be required to ensure greater public participation in the selection of future plant sites. In such cases the Board believes that its procedure of conducting a preliminary review of an application for approval of a site and advising the applicant of the results of such review is in the public interest (Conditional Site Approval). If no major obstacles are apparent at this stage, the applicant may then make a public announcement of his intention to proceed with the project and arrange for public participation in review of the proposal. One provincial utility now has a policy of holding public meetings on all major projects, not only nuclear projects.

It is the practice of the Board to require that there be an interval of the order of six weeks between an official announcement of the utility's intent and the Board's approval of the site.

The Board is not empowered to hold formal public hearings, as I mentioned before, but if there is sufficient cause it would arrange public meetings to allow interested parties to give their views and ask questions. The outcome of any public comment will be taken into account by the Board in the final consideration of the application for site approval.
The issuance of a Site Approval represents the opinion of the Board that the site is considered to be suitable for the construction of a reactor of the size and type described in the Site Evaluation Report.

Following the issuance of a Site Approval, the utility's next step in seeking regulatory authorization is to submit an application for a Construction Licence. In so doing, the applicant also submits a Preliminary Safety Report the purpose of which is to document the information essential to a comprehensive evaluation of all the factors involved in ensuring that the health and safety of the public (including the station operating staff) would be protected should the station in question be constructed. The Preliminary Safety Report is a collection of siting and environmental data, design and procedural considerations, process and safety system descriptions and performance specifications and those safety analyses upon which the necessary licensing decisions can be made -- basically those affecting the design of the containment and major process systems.

The Preliminary Safety Report is reviewed by the Reactor Safety Advisory Committee and by the Board staff. Officers of provincial regulatory agencies concerned with such matters as boiler and pressure vessel design, construction and inspection are also consulted. During the review, meetings are held with the designers to obtain such additional information as may be required for an in-depth assessment of the safety of the proposed station. If the Committee and the AECB staff are satisfied with the proposed design, they recommend to the Board the issuance of a Construction Licence. One condition included in the licence is a requirement that the Preliminary Safety Report be updated annually as the detailed design and construction of the station proceed.

The granting of a construction licence does not imply acceptance of every argument or conclusion in the Safety Report. The Reactor Safety Advisory Committee and the Board staff, while not accepting the specific claims made for certain aspects of the design, may conclude that they are adequately safe. For example, the report may claim an extremely low unreliability for a component or system, whereas the Committee, while not endorsing the value quoted, might accept the system as adequate in the context of the general safety requirements.
The Committee meets again several times while construction is in progress, to consider details of design that are developed as construction proceeds. It may request additional information, or require that certain tests be performed during construction. Sometimes it requests design changes; for example, the unique "negative pressure containment system" first used at Pickering was proposed by the designers as a result of the Reactor Safety Advisory Committee's insistence on a very high degree of safety.

When construction nears completion, the utility may apply for issuance of an Operating Licence. In so doing, the utility submits a final Safety Report to document the "as built" design of the station, the updated analyses of postulated accidents and the capability of safety systems to prevent or limit the consequences of such postulated accidents.

The Reactor Safety Advisory Committee and the Board staff review the final design, results of tests and plans for operation. Only when it is determined that the plant has been designed, constructed, commissioned and staffed adequately, and that it can be operated safely, does the Committee recommend to the AECB that an Operating Licence be granted.

Permission for full operation may be preceded by two substages of authorization: 1) permission to load fuel; and 2) permission to start up. The issuing of the Operating Licence then implies acceptance by the Board of the safety aspects of the plant as constructed.

At least one staff member of the AECB is located at a station during commissioning and remains at the reactor site after start-up until routine operation is achieved, to observe the various start-up tests and assess their results, to consider requests for changes in the method of operation, and to give the AECB independent assurance that the nuclear plant is being operated safely. The AECB staff and the Reactor Safety Advisory Committee continue their surveillance of the operation of the nuclear plant throughout its life.
Another important aspect of the licensing process is the authorization of the plant staff. The organization of staff and senior members of the operating staff, must all be approved. The experience and educational qualifications of the key operating staff of a nuclear plant are examined by the staff of the Board in the light of requirements established by the AECB on the advice of a Reactor Operators Examination Committee. This Committee includes experts in reactor operation and radiation safety as well as representatives of the provincial licensing bodies for steam plant operators. In addition to possessing the necessary experience and educational qualifications, those nuclear plant operators designated as Shift Supervisors or Control Room Operators must also write examinations set by the Board that cover the theoretical and practical aspects of operating the nuclear and conventional equipment, and of radiological protection.
4. DESIGN CRITERIA AND STANDARDS DEVELOPMENT

In the Canadian context, the design criteria and safety criteria or philosophy are so interrelated that it is difficult to discuss them separately.

Basically, all safety criteria are directed toward minimizing the chance of mechanical failure of the fuel and to preventing or minimizing the escape of fission products from the plant if fuel failure occurs. The basic tenet of the Canadian reactor safety philosophy is the one of defence-in-depth. One of the most important aspects of a defence-in-depth philosophy is the prevention of upset conditions and accidents which threaten the integrity of the fuel sheath and the primary coolant system, reactor control system and other systems associated with the normal operation of the plant are referred to as the process systems. These systems must be designed, constructed and operated to high standards. A quality assurance program is required to ensure that the standards specified are indeed achieved. More about Q.A. later.

A number of special safety systems are also included in the design of the plant. The protective shutdown system or systems (current designs employ two such systems) are designed to shut down the reactor rapidly should process parameters exceed certain limits. The emergency cooling system acts in conjunction with the protective shutdown system to limit fuel failures in the unlikely event that normal cooling of the fuel is lost because of a failure in the primary coolant system. The third physical barrier, the containment, is also a special safety system. The word "special" in the term "special safety systems" is an acknowledgement of the importance of the process systems in the safety of the plant.

One can also consider the first line of defence in the defence-in-depth philosophy as being the process systems. Despite the high standards for the reliability required of these systems, designers must examine postulated serious failures within the process systems to provide the basis for design of the special safety systems and to develop the defence-in-depth approach.
Similarly, despite the stringent requirements for reliability and effectiveness of the special safety systems, the designer is obliged to consider the same spectrum of serious process failures as before combined with malfunctions in each of the special safety systems in turn. These are referred to as "dual" failures. These analyses also set certain requirements for the various special safety systems because the calculated consequences of such postulated accidents must be within limits set by the safety criteria.

Looked at in the foregoing way the defence-in-depth concept can be considered as, first, prevention of serious failures in process systems; second, limiting the consequences of serious failures in process systems; and third, limiting the consequences of serious failures in the process systems combined with failure of any one of the special safety systems.

The requirement for a high standard of reliability of systems such as the reactor power-regulating system and of all special safety systems is itself very comprehensive and is illustrative of how the defence-in-depth approach is achieved. The reliability required of a protective shutdown system is achieved by providing three completely independent "channels" of protection. Any two channels in the system will perform the required protective function thus allowing for the unavailability of the third without affecting the overall operation of the system. This triplication increases reliability by permitting testing of each channel individually for the purpose of assessing system reliability and allows routine maintenance work to be carried out during high power operation of the reactor. One additional and very important feature is the design of the protective shutdown system in such a way that should one channel be undergoing testing, the reactor will automatically shutdown should either of the remaining two channels detect an unsafe condition.

Avoidance of human errors is an extremely important part of the Canadian safety philosophy. The multiple consequences of a single error (either in design, construction or operation) may defeat the purpose or impair the operation of
even a triplicated system. Recognition of this possibility at an early date further reinforces the importance of a defence-in-depth approach and has resulted in the application of this basic philosophy in the case of every CANDU power reactor. In practical terms, the requirement means that a rigorous review of the proposed design, construction and operating procedures for each reactor must be carried out to ensure that the consequences of a human error will be limited to a single event which involves only one channel in a triplicated system or is protected against by one or more of the other systems available because of the defence-in-depth approach.

In applying the basic Canadian philosophy just described, a number of specific criteria and principles have evolved.

First, design and construction of components, systems and structures essential to or associated with the reactor shall follow the best applicable code, standard or practice and be confirmed by a system of independent audit.

Second, the design, quality and operation of all process systems essential to the reactor shall be such that the total of all serious failures does not exceed 1 per 3 years. A serious process failure is one that in the absence of protective action would lead to serious fuel failure.

Third, special safety systems shall be physically and functionally separate from the process systems and from each other to the maximum extent practicable.

Fourth, each special safety system shall be readily testable, as a system, and shall be tested at a frequency to demonstrate that its (time) unreliability is less than $10^{-3}$.

Fifth, radioactive effluents due to normal operation including process failures other than the coincident or "dual" failure to which I will refer again in a minute, shall be such
that the dose to any individual member of the public affected by the effluents, from all sources, shall not exceed \( \frac{1}{10} \) of the allowable dose to Atomic Radiation Workers and the total dose to the population around the reactor site shall not exceed \( 10^4 \) man-rem per year.

Sixth, the effectiveness of special safety systems shall be such that for any serious process failure the exposure of any individual shall not exceed 500 mrem and of the population at risk, \( 10^6 \) man-rem.

Seventh, for any postulated combination of a single process failure and failure of a special safety system (referred to as a "dual" failure), the predicted dose to any individual shall not exceed 25 rem to the whole body or 250 rem to the thyroid, and for the population, \( 10^5 \) man-rem.

These criteria are used by the licensees as their bounds for designing and operating the power plants.

I would like now to speak a bit about standards and their development. (Dr. Rosen mentioned the IAEA Codes and Guides – our definition is different.) Canadian and international codes have been applied in the design, manufacture and installation of components for Canadian nuclear power stations but much remains to be done in this field. In the early days of the nuclear industry, existing construction, manufacturing and inspection codes were pressed into service with ad hoc modifications to allow for the special needs of nuclear service but with little if any attention to the longer term requirements such as in-service inspection. This situation could not be tolerated for long and the developments of the last few years have readily demonstrated the widespread recognition of this fact.

Because certain of the features of Canadian power reactors are unique, some sections of the ASME Boiler and Pressure Vessel Code are not fully applicable to CANDU reactors. In particular, Section XI ("In-Service Inspection of Nuclear Reactor Coolant Systems") does not deal with the special
requirements appropriate to in-service inspection of thin-walled pressure tubes simply because the document was prepared in respect of a reactor type in which the major reactor-boiler component is a thick-walled pressure vessel. Consequently, the need for Canadian standards appropriate to Canadian conditions and requirements is readily apparent.

Through the joint efforts of the Canadian Nuclear Association and the Canadian Standards Association, considerable effort is currently underway in preparing a number of standards which will take into account Canadian requirements and the unique features of Canadian power reactors -- this is considered to be a consultative approach.

These standards are being published as national standards, and in their initial form they are intended for trial application and comment. The ultimate objective of this standards-writing program is to make available to the industry and the utilities in general, a complete and readily accessible set of reference documents that reflect the various and numerous successful nuclear power station practices that have been developed. The following standards have been prepared and published so far as part of the program, and are presently in use:

- CSA N285.4 Periodic Inspection of Candu Nuclear Power Plants
- CSA N287.1 Requirements for Concrete Reactor Containment
- CSA Z299.1 Quality Assurance Program Requirements
- CSA Z299.2 Quality Control Program Requirements
- CSA Z299.3 Quality Verification Program Requirements
- CSA Z299.4 Inspection Program Requirements

A number of other standards covering other areas are to be issued in the near future.

It is self-evident that the transition from a situation in which reactor design and approval were carried out on
a case-by-case basis using the well-known "first principle" approach to one in which design requirements are codified will involve problems of interpretation and back-fitting when changes to existing plants are required. These problems have and are being experienced insofar as existing nuclear power stations are concerned. Hopefully, these problems will remain limited in number and application, but this will only be so if the preparation of Canadian codes is expedited.

To aid the industry in proceeding through the licensing process, the Board uses the mechanism of Licensing Guides to record and to communicate to industry Board requirements concerning the more important safety principles, practices, and licensing procedures associated with nuclear power stations, heavy water plants, radioactive waste management, and any other equipment or activities within the AECB's jurisdiction.

A secondary, but nonetheless important purpose of the Guides, is to stimulate nuclear standards-writing activity by the industry, since the Guides themselves will not generally include very detailed requirements.

However, where safety needs are such that detailed requirements must be stated, and where no codes, standards or other suitable documents exist, detailed requirements may be specified in these Guides. Even though the Guides will deal with requirements of considerable importance they will not be written in mandatory language. Thus, the way will be left clear for applicants and licensees to propose alternate approaches for consideration. Any such deviations from the Guides of course, would have to be justified by the proposer to gain Board approval.

While still subject to scrutiny, the proposals of applicants and licensees complying with Guide requirements would be basically acceptable to the Board and would be judged from the outset to pose no special licensing difficulties.
5. **INSPECTIONS AND ENFORCEMENT**

Use is made of AECB Project Officers to coordinate the examination of licensee's submissions and to perform the compliance audits. One or more of these officers is assigned to each project in a non-resident (with regard to the project site) or resident capacity, depending on the stage the project has reached.

Compliance checking and auditing is done by the Project Officer and this activity continues through to commissioning, reactor start-up and early operation of the station. The issuance of an Operating Licence to the station owner depends in large measure on the detailed conclusions of the resident Project Officer and his associates.

Once the station settles down to routine, mature operation, past practice has been to close the on-site AECB office and have the Project Officer return to the Head Office. This practice could well change for large, multi-unit stations. With these plants, the decision may be taken to maintain the on-site AECB office on a more permanent basis.

At the present time, however, once an on-site office has been closed, routine compliance checking of the operating station is carried out by a non-resident Project Officer located at Head Office. This checking continues for the life of the station and involves regular, short-term visits to the facility. Checking is also conducted by means of regular operating and related reports filed by the licensee with the AECB Head Office.

The primary objective of regular inspection visits is to ensure that each facility is being operated in accordance with the Reactor Operating Licence in effect at the time, as well as the several technical and administrative documents to which the licence refers.

As an adjunct to this, routine facility visits by inspectors tend to increase the licence discipline of the
licensee organization indicating clearly the seriousness of the AECB towards ensuring compliance with the licence.

A further important objective is the establishment of a rapport between the inspector and facility staff enabling cooperative consideration of any operating difficulties, future plans, and other matters of mutual interest. Based on the need for the inspector to be an identifiable person at the facility, the frequency of visits is normally once per month. If it is reasonably possible, we would like to increase this frequency to two visits per month. The major activity of the inspector is a discussion with the senior facility technical staff member to review operation during the previous inspection period.

In addition, the inspector examines the control room operating records covering the previous inspection period. He may subsequently examine in more detail the radiological records maintained by the facility staff and hold discussions with the Senior Health Physicist and/or the Radiation Protection Supervisor on the status of radiation protection of personnel at the station.

There is a procedure for action by a Project Officer should operating deficiencies come to his attention during discussions with station or other personnel, physical inspections and review of operating records or other documents.

He first discusses the matter with Station Management to confirm the facts on which the case is based; then he ensures that there is agreement between Board Staff and Station Management that the event(s) under discussion represent a violation of the Operating Licence and/or approved operating procedures; then he determines if there were any extenuating circumstances; and also allows an informal exchange of views on how similar violations could be avoided. Such violations could, in the extreme, result in revoking of the licence, or according to the Atomic Energy Control Act, persons or companies or corporations who fail to observe the provisions therein are liable to fines and imprisonment.
6. **CONCLUSION**

I'm certain that, in the foregoing, I've missed some significant areas of interest to you and emphasized some aspects more than is really necessary in this context. I hope you will take the opportunity to pursue your own topics of interest during the upcoming panel sessions in which I will be involved and also at any other convenient time when there is no formal program underway.

Let me conclude with a general remark and a matter-of-fact question which you should be asking yourself: There are two extremes to any form of regulation - either you trust the person completely or you don't trust him at all. Where your nuclear regulatory system falls between these two extremes depends on many and varied influences, some of which I mentioned at the beginning.

To what extent, then, can you trust, or can you afford to trust, the ones who are making application to you, the regulatory body responsible to the public for the health and safety aspects of nuclear facilities? This is the question you must ask yourself regularly in order to determine the type of regulatory system best suited for your purposes.