My purpose today is to describe to you from the viewpoint of the AECB staff, something of the background and events against which requirements for the in-service inspection of CANDU reactors have been developed.

In-service inspection is but one of a number of different activities which individually aim at preventing the occurrence of a nuclear accident, which could seriously affect the operating staff of a nuclear power station and the public. The context of in-service inspection is thus, reactor-safety.

Before proceeding to discussion of in-service inspection, I believe it would be worthwhile to say a few general words about reactor safety. The basic safety of a nuclear reactor plant remains an important and ever-present consideration from the time the plant is conceived and a site is selected, through the design, construction and operation phases to the plant's final decommissioning.

The major objective of reactor safety is to ensure in a preventive way, that radionuclides formed within the reactor fuel as by-products of the nuclear fission process, and by activation, remain securely sealed up behind the sheathing containing the fuel. Any postulated accidental occurrence which could lead to failure of the fuel sheathing and therefore release of significant quantities of fission products and other radionuclides is studied closely as is the course of events which could follow such a release.

The word "significant" is used deliberately, since limited "small" failures in fuel sheathing will not represent a serious hazard, provided the reactor coolant system is of high integrity and does not therefore allow the fission products to emerge. Limited quantities of fission products entering the coolant system may be removed by an off-gas system or may remain dissolved in the coolant until they decay.

The overall reactor safety philosophy which has been developed over the years, and which addresses the fission product release concern, in fact possesses a number of features which are either "accident preventive" or "accident limitive", in nature. As already implied, application of this philosophy leads initially to major emphasis being placed on the provision of reliable, high quality nuclear process systems and equipment to prevent the occurrence of accidents, or at least to ensure that serious accidents are only very low probability events.
In addition, however, special safety systems and equipment are also provided to limit the consequences of such events should they occur. These special safety systems are themselves of high quality, similar to that of the process systems. This conservative dual approach leads to the provision of a number of high-quality, physical barriers arranged in series between the fission products in the fuel and the environment, which is sometimes referred to as "defence-in-depth".

The postulated nuclear process system accident which poses the most serious challenge to the general objective of securing the nuclear fuel fission product inventory is extreme failure of the reactor coolant system. On the "accident limitive" side, such special consequence-limiting equipment as an emergency core cooling system, and a containment system, are provided to meet this challenge and to ensure that, despite an extreme failure, fission products will not emerge into the environment in significant quantities. On the "accident preventive" side, effort to avoid extreme coolant system failure includes vigorously controlled and disciplined system design, manufacture, installation, commissioning, and operation of the system and the other equipment interfacing with it, or influencing it.

In recent years, the planning and management of the operation of power stations has been extended to include in-service inspection as a further "accident preventive" activity.

The first organized, long-term inspection program for a Canadian nuclear power station was put into effect at the four-unit Pickering "A" Generating Station, Ontario. This program, which was established and accepted in 1973, grew out of lengthy discussions between Ontario Hydro and the Atomic Energy Control Board staff and its advisors. Some in-service inspections of a preliminary, investigatory nature had already been conducted earlier, however, in 1971 and 1972, at the NPD Generating Station, Ontario. These early inspections represented a grappling with some of the problems associated with restricted access inspection in a hostile environment, combined with a sincere attempt to assess the integrity of major components in a ten year old plant.

While each of these undertakings at the two stations was thoughtfully planned and appeared, at the time, capable of meeting the overall integrity assessment objective, it was clear that a real need existed for intensive study of the subject leading to establishment of a reference document containing agreed requirements for in-service inspection programs. Without such a document, the future promised station to station program inconsistencies, probable inadequacies, and near-endless arguments between the AECB and its advisors on the one hand and reactor licensees on the other.
While this concern for the need for a uniform set of inspection requirements was apparent, it is interesting to note that a standard on in-service inspection did exist at the time. In fact, the American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code, Section XI, entitled "In-Service Inspection Requirements for Nuclear Power Reactor Coolant Systems" was first promulgated as a formal standard in 1970. Prior to that time, the standard had been available in draft form. To some extent, the early inspection work at the NPD Generating Station and also the long-term program accepted for the Pickering "A" Generating Station embodied principles contained in the ASME, Section XI document. However, the licensees and their nuclear consultants argued most strongly that, in its complete form, the ASME standard was not appropriate for inspection of pressure-tube type reactors such as CANDU.

While not completely unsympathetic to these claims, the Atomic Energy Control Board stated in 1973 that, in the absence of a possibly more suitable CANDU inspection standard, the Section XI standard would be the governing document for in-service inspection at the four-unit Bruce "A" Generating Station and for all subsequent stations. This pronouncement was an important factor in the decision to form a Canadian Nuclear Association (CNA) Committee to prepare a suitable preliminary standard, specifically addressing periodic in-service inspection of CANDU reactor components.

The Committee brought together all interested parties including representatives from the nuclear system designers, consultants, the electric power utilities, and the provincial and federal jurisdictions. These individuals began their joint task working from first principles; initially defining the objectives and then working towards the establishment of a philosophy and detailed requirements to lead to attainment of those objectives. I would like to very briefly summarize these steps and particularly, to touch on one or two key principles that emerged as the inspection requirements and criteria developed. I should emphasize that individually, these principles I am referring to, and most of the others which are inherent in the current Canadian standard, are not novel, but that collectively, in the context of a nuclear power station, they do represent a new approach.

In its most complete form, in-service inspection is organized, systematic integrity assessment of the reactor coolant system and other important pressure envelopes by means of physical examination.
Within the general objective of failure prevention, the activity has three immediate objectives. The first is assessment of the integrity of the system being addressed at the time of inspection; the second is an understanding of the changes which have taken place in the system since the previous inspection; the third is assessment of the system changes likely to occur during the next operating period.

The inspection philosophy was developed to enable accomplishment of these activities. Two fundamental principles of this philosophy are that the extent of inspection of components and systems should be based on the likelihood of postulated failures as suggested by stress considerations, and also on the consequences of the failures as indicated by the degree to which the "accident limitive" special safety systems would be challenged should the failures actually occur. Another important principle is that implementation of an inspection program should not lead to excessive man-rem exposure; conversely, however, high radiation fields around components should not automatically result in modification of the inspection planned for those components. In developing the requirements, recognition was also given to the fact that reactor in-service inspection was, and still is, a relatively new activity and that generic changes in inspection programs might be highly desirable in the face of accumulating data and experience.

These and very many other deliberations by the Committee culminated in February 1975 in the official issue by the Canadian Standards Association of preliminary standard CSA N285.4, entitled "Periodic Inspection of CANDU Nuclear Power Plant Components".

I believe that my colleagues from Atomic Energy of Canada Limited, and the electric power utilities will be speaking further on the detailed content of CSA N285.4.

In discussing the integrity of nuclear pressure-retaining components, I should be remiss indeed if, as a member of the AECB, I failed to acknowledge the contributions which have been made by the provincial government agencies. These contributions have not been limited to the overseeing of in-service inspection alone.

In pursuing its concern with reactor safety through assurance of the integrity of nuclear pressure-retaining components, the AECB staff has been fortunate to have had the benefit of good working relationships with the provincial jurisdictions normally responsible for registration and inspection of such components in conventional plants. A strong spirit of
co-operation has developed so that the detailed expertise and experience of the staff of these agencies with conventional components has been made freely available in the nuclear power station context to the Atomic Energy Control Board staff. This accumulated expertise has been brought to bear in the development of the CSA N285.4 document.

During the short history of in-service inspection so far the practice briefly has been for the AECB staff to consult with the appropriate provincial jurisdiction on the adequacy and acceptability of a licensee's documented inspection program proposal. Once the program has been formally accepted and put into effect, its implementation is checked by the AECB and the provincial jurisdiction, who collaborate jointly in the dispositioning of any significant defects discovered during inspection. We of the AECB staff look forward to long-term continuation of provincial jurisdictional support and advice in this area.

To summarize: a safety-oriented jurisdictional requirement for organized, systematic and effective periodic in-service inspection of important reactor components was first made known in 1971. This led to the formation of a special CNA Committee and discussion and development of a set of reference requirements and criteria in a preliminary standard CSA N285.4 written expressly for CANDU reactors. While the standard has had only limited use so far and still must be thoroughly and extensively applied to determine its validity, it is believed to be basically sound in approach and the expectation is that it will prove to be an important contributor to overall nuclear power plant safety.
IN-SERVICE INSPECTION OF HEAVY WATER PRODUCTION PLANTS

At the present time, there is no formal AECL requirement for the periodic in-service inspection of heavy water production plants.

However, licensees currently carry out on their own initiative, inspection of major components at regular intervals. These inspections lead to assessment of pressure envelope integrity from both the point of view of safety and plant production reliability.

There is a distinct possibility that at some future time, the AECL will require that licensees establish periodic programs for systematic in-service inspection.

I believe that in many respects, the announcement of such a requirement would set in motion the same kind of jurisdiction, industry exchanges and co-operation that has led to the development of CSA N285.4. Certainly, the same principal need would exist; that of a standardized set of rules to permit consistent program establishment, implementation and evaluation.

The very significant differences in the nature of the two types of plant (a HWP and a reactor) suggest that CSA N285.4 would be of limited direct use for the inspection of HWP's, except as an example of what can be done.