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CANADIAN PROGRAMS ON UNDERSTANDING AND MANAGING AGING DEGRADATION OF NUCLEAR POWER PLANT COMPONENTS

by

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Paper

CANADIAN PROGRAMS ON UNDERSTANDING AND MANAGING AGING DEGRADATION OF NUCLEAR POWER PLANTS COMPONENTS

A report prepared by J.A. Chadha, Ontario Hydro, and J. Pachner, Atomic Energy Control Board.

ABSTRACT

The questions of maintaining adequate safety and reliability of nuclear power plants and the questions of nuclear power plant life assurance and life extension are growing in importance as nuclear plants get older. Age-related degradation of plant components is complex and not fully understood. This paper provides an overview of the Canadian approach and the main activities and their results towards understanding and managing age-related degradation of nuclear power plant components, structures and systems. A number of pro-active programs have been initiated to anticipate, detect and mitigate potential aging degradation at an early stage before any serious impact on plant safety and reliability. These programs include Operational Safety Management Program, Nuclear Plant Life Assurance Program, systematic plant condition assessment, refurbishment and upgrading, post-service examination and testing, equipment qualification, research and development, and participation in the IAEA programs on safety aspects of nuclear power plant aging and life extension. A regulatory policy on nuclear power plants is under development and will be based on the domestic as well as foreign and international studies and experience.

RÉSUMÉ

Les questions relatives au maintien d'un niveau approprié de sûreté et de fiabilité des centrales électronucléaires, ainsi qu'à l'espérance de vie et à la prolongation de vie de ces centrales, sont de plus en plus importantes à mesure qu'elles vieillissent. La dégradation par vieillissement des composants des centrales est complexe et n'est pas complètement éclaircie. Le présent rapport fournit un aperçu de l'approche canadienne, de même que des activités et de leurs résultats pour mieux comprendre et traiter la dégradation par vieillissement des composants, des structures et des systèmes de centrales électronucléaires. Certains programmes proactifs ont été mis en vigueur pour prévoir, déceler et atténuer la dégradation potentielle par vieillissement assez tôt avant que toute répercussion grave sur la sûreté et la fiabilité de la centrale se produise. Ces programmes comprennent le Programme opérationnel de gestion de la sûreté, le Programme d'espérance de vie des centrales nucléaires, l'évaluation systématique des conditions des centrales, les remises à neuf et les améliorations, les examens et les épreuves après réparations, la certification du matériel, la recherche et le développement, ainsi que la participation aux programmes de l'AIEA au sujet des aspects du vieillissement et de la prolongation de vie des centrales électronucléaires qui se rapportent à la sûreté. Une déclaration de principe en matière de réglementation concernant le vieillissement des centrales électronucléaires est en train d'être rédigée et sera basée sur les études et l'expérience canadiennes, étrangères et internationales.

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The questions of maintaining adequate safety and reliability of nuclear power plants and the questions of nuclear power plant life assurance and life extension are growing in importance as nuclear plants get older. Age-related degradation of plant components is complex and not fully understood. This paper provides an overview of the Canadian approach and the main activities and their results towards understanding and managing age-related degradation of nuclear power plant components, structures and systems. A number of proactive programs have been initiated to anticipate, detect and mitigate potential aging degradation at an early stage before any serious impact on plant safety and reliability. These programs include Operational Safety Management Program, Nuclear Plant Life Assurance Program, systematic plant condition assessment, refurbishment and upgrading, post-service examination and testing, equipment qualification, research and development, and participation in the IAEA programs on safety aspects of nuclear power plant aging and life extension. A regulatory policy on nuclear power plants is under development and will be based on the domestic as well as foreign and international studies and experience.

1. INTRODUCTION

1.1 Aging Population Nuclear Power Plants

The nuclear community is facing new challenges as the first generation of commercial nuclear power plants (NPPs) grow old. Some of these plants are approaching or have even gone beyond the end of their nominal design life, which, for most of the first commercial designs, was 25-30 years. Worldwide, a projection from the current NPP age profile shows that, in 1990, 37 plants will reach the age of 25 years, and 14 plants the age of 30 years. The respective figures will increase to 160 and 69 plants in the year 2000 [1].

The present age distribution of Canadian NPPs is shown in Table 1. Since there are no new plants on order after the Darlington NPP, the current average NPP unit age of 9 years will be increasing in the foreseeable future. At present, only two Pickering A units are 18 years old, but without new plants by the year 2000, the average Canadian unit age will be 18 years. Because of the strategic importance of nuclear power, the question of maintaining the safety and reliability of rather "old" plants, and questions of plant life assurance and life extension, is thus of growing importance.

1.2 Ontario Hydro Experience with Aging of Fossil Power Plants

The performance and reliability of power plants, their systems and components, may decline during the middle and later years of their life. These effects have been observed on Ontario Hydro's (OH) fossil plants and similar trends are expected for nuclear plants[2]. For example, OH's program of plant life extension at Lakeview Thermal Generating Station has revealed a number of age-related problems with plant equipment. A major cause of these problems was lack of preventive maintenance. To extend Lakeview's service life by 15 years, a 1.1 B$ program of rehabilitation and replacements has been started at this station. A similar plant life assurance program has been initiated at OH's Lambton Thermal Generating Station. The reliability of this plant has decreased over the last few years - the forced outage rate went up from 2 to 7 percent in the last 6 years. It is expected that OH may have to spend over 300 M$ to ensure safe and reliable service for the 35-year nominal service life.

1.3 NPP Age-Related Issues

The term "aging", as used in NPP aging and life management[1] work, refers to the continuing, time-dependent degradation of materials and plant components[2] due to plant service conditions. Aging phenomena include chemical and physical processes, such as corrosion, creep, fatigue, irradiation and thermal embrittlement, and service wear. These processes occur under design service conditions (which include environmental, loading, and power conditions) and may be accelerated by departures from the design specifications caused by improper storage, faulty installation, excessive testing, incorrect operation and poor maintenance. All NPP materials experience aging effects to a greater or lesser degree which leads to functional degradation of plant components. The impact of this age-related degradation has to be assessed in terms of answers to the following questions:

1. Is the plant safe to run?
2. Is the plant equipment in sufficiently good condition that the risk of catastrophic failure is reasonably low?
3. Is the plant equipment in sufficiently good condition to ensure high reliability?
4. Is the plant economic compared to other nuclear or fossil plants, or new generating stations?
5. Is the plant able to meet regulatory, political, and social requirements?

Because of the potential negative impact of the aging of NPP components on plant safety and reliability and the potential economic benefits of NPP life management, various organizations in many countries are devoting significant resources and effort to better understanding and managing the effects of aging. This paper provides an overview of Canadian programs designed to understand and effectively manage NPP aging. The paper emphasizes a systematic and an integrated approach to managing age-related degradation of NPP components.

2. CANADIAN PROGRAMS ON NPP AGING

The goal of the Canadian programs on understanding and managing aging of NPP components is to maintain plant safety, reliability, and economics throughout the entire plant service life, that is, the nominal and any extended service life. Utilities have been using a number of programs such as preventive maintenance, inspection, monitoring, periodic review of NPP performance, and feedback of operating experience to detect, remedy, and mitigate the effects of failure of NPP components due to any cause including the effects of aging. These methods have been quite effective in dealing with aging up until now. However, because of the increasing age of plants, there is a need for integrated and systematic programs to understand and manage aging. The major Canadian programs in the area of NPP aging are listed below. All of the programs discussed below are pertinent to both safety and reliability aspects of NPP aging, although to a different extent.

(1) Operational Safety Management Program
(2) Nuclear Plant Life Assurance Program

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1. NPP "life management" is used in a broad sense and includes plant life assurance as well as life extension.

2. In this paper, the meaning of the term "components" includes also plant systems and structures.

(3) Plant Refurbishment and Upgrading Programs
(4) Aging Studies Using Components from Decommissioned NPPs
(5) Equipment Qualification
(6) Research and Development
(7) IAEA Aging Program Participation
(8) Regulatory Policy Development

The programs under items 1, 5, and 8 are aimed primarily at managing the aging of components in safety-related systems. The Nuclear Plant Assurance Program on the other hand, focusses on managing the aging of a relatively few "big ticket" plant components. Programs under items 3, 4, 6, and 7 are of a generic nature and the results are applicable to understanding and managing aging of all plant components. The highlights of these programs are presented in the following sections.

3. OPERATIONAL SAFETY MANAGEMENT PROGRAM

The operational safety management program [3] consists of a preventive maintenance program; the Significant Event Report system; and a reliability-based assessment of the performance of safety related systems. These methods play an essential and complementary role in preventing, detecting, correcting, and mitigating failures of NPP safety-related systems and components from all possible causes, including aging, and in achieving a high level of plant safety and reliability.

Preventive maintenance programs include inspections, testing, surveillance, repair, and replacement activities designed to preserve functional capability of NPP components for operational and emergency use. These activities are used to a greater extent in maintaining the required level of performance of safety equipment compared to that of process equipment. They are also the primary means of detection and mitigation of aging effects in NPP components.

In Canada, at present, most of the preventive maintenance is in the form of scheduled maintenance which is based on a call-up system. In future, greater emphasis will be on predictive maintenance which is based on condition monitoring of selected components. Upgrading of present record keeping systems is planned to facilitate analysis of relevant data (condition monitoring data, operational and maintenance history data, baseline data and acceptance criteria) and reporting of trends so that the extent of component degradation can be determined and a decision on the type and timing of maintenance made.

The purpose of the **Significant Event Reporting System** is to control and limit the risk associated with NPP operation through systematic detection, analysis and correction of deficiencies, including those caused by aging degradation:

- a multi-level diverse screening process includes reviews of Significant Event Reports (SERs) by plant staff and management, different head office groups, a senior management review committee (when needed), and regulatory staff;
- trends of equipment and system deficiencies, identified by the SERs, and their causes are monitored; and
- lessons learned from SERs are communicated to other CANDU stations, owners, designers, and equipment manufacturers.

The effectiveness of an SER system to identify and evaluate component failures caused by aging effects is limited by lack of readily retrievable relevant data, such as failure mode and cause, service life, service conditions and baseline data. The above upgrading of operational and maintenance record keeping systems related to preventive maintenance would also improve the efficiency and effectiveness of the SER system in identifying age-related component failures and most appropriate corrective actions.

Reliability-based assessment of performance of safety-related systems is an important part of the annual comprehensive and systematic review of nuclear power plant operation and maintenance. It allows identification of deteriorating performance and corrective actions based on analysis of such performance. Performance is measured against standards or targets which are established by the utilities on the basis of regulatory requirements, internal and external experience, international recommendations and other considerations.

For poised systems, that is, systems which are normally inactive and are triggered on demand, a test program is developed and implemented to provide confidence that the system will work when needed. Components or functions to be tested and the test frequency are determined using reliability analysis and adjusted on the basis of in-service experience.

Reliability surveillance groups at NPPs monitor daily test records, control room logs, work reports and deficiency reports to ensure that all reactor safety deficiencies are properly recorded, classified as to their severity, and corrected.

To assess performance of poised safety-related systems, several reliability indicators are evaluated and monitored, including system actual inoperability and system actual and expected unavailabilities. The component failure rate monitoring program annually evaluates component failure rates and compares them to component lifetime experience and generic failure rate data.

Monitoring and assessing performance of process systems involves recording and trending of both actual and near-miss serious process failures. Should either of these trends indicate a potential problems, a more detailed review of all component faults of a system is carried out to determine major contributors to undesirable performance and appropriate follow-up actions.

4. NUCLEAR PLANT LIFE ASSURANCE PROGRAM

A formal Nuclear Plant Life Assurance (NPLA) program [4,5] has been initiated for OH's nuclear power plants with the following main objectives:

(1) To maintain the long-term reliability, availability, and safety of OH's nuclear plants during the nominal service life of 40 years (life assurance).

(2) To preserve the option of extending the life of OH's nuclear plants beyond the nominal service life of 40 years (life extension).

The main emphasis of the program is to shift the balance in the mode of operation and maintainance from a reactive mode to one of prediction and prevention. The program focuses on a relatively few major components that are most critical to the long-term reliability, safety, and life of the plant since they cannot be easily and economically replaced. A list of such critical components has been prepared for the lead (oldest) commercial plant, Pickering NGS-A, and is shown in Table 2.

Table 2

LIST OF CRITICAL COMPONENTS FOR PNGS-A

1 Fuel Channels
2 Steam Generator
3 Calandria Vessel
4 Reactor Headers, PHT Piping, Pressurizer, & General Nuclear Piping
5 Calandria Supports
6 Secondary Piping
7 Vacuum Building
8 Calandria Vault & End-Shield Cooling Systems
9 Cables (power, control, and instrument cables)
10 Reactor Building
11 Turbines
12 Generator
13 Digital Computer System
14 Cooling Water Intake Structure
15 Spent Fuel Bay/Liner
16 Penetrations and Airlocks

The NPLA program for OH's nuclear power plants has been divided into the three phases of: methodology, scoping, and implementation. Significant input from international studies and various OH Divisions was received and used in the development of the program.

The NPLA methodology for an assessment of age-related degradation and for an engineering evaluation of critical components has been developed. Key elements of the methodology are presented below:

- Identify and understand age-related degradation mechanisms through an analysis of operating and maintainance history, and through research and development.
- Perform an assessment of the present condition of critical components to determine the extent of age-related degradation, and predict remaining service life.
- Initiate new programs of inspection, monitoring, and surveillance to ensure early detection of age-related degradation so that preventive measures can be taken before failure or loss of function.
- Identify changes in operating and maintenance procedures to prolong component service life.
- If required, identify programs of critical component repair, refurbishment, or replacement to restore its degraded functional capability.

The main objective of the scoping phase is to define new NPLA initiatives and long-term studies related to each critical component. The scoping studies are conducted in a systematic and comprehensive manner by following the step-by-step methodology outlined above. The basic data required for scoping studies includes items such as original design documentation, list of potential known and unknown degradation mechanisms, operating and maintenance history data for the component, commissioning and in-service inspection data. The output of the Scoping Phase is a list of new NPLA initiatives related to inspection, maintenance, rehabilitation, and research and development for each critical component. In arriving at these new initiatives, the effectiveness of the existing programs is being taken into account.

The preliminary scoping studies for Pickering NGS-A are now complete. The implementation phase (Phase 3) will begin soon after the acceptance of scoping phase recommendations by the station technical staff.

Canadian nuclear plants are fairly young and the costs associated with the plant life assurance activities have been small to date. The potential long-term benefits of the NPLA program are expected to be high as indicated by preliminary economic assessments of plant life extension, e.g. [6,7]. Thus it is felt that even though the actual costing for OH plants has not yet been done, the program is expected to have a high benefit to cost ratio.

5. PLANT REFURBISHMENT AND UPGRADING PROGRAMS

5.1 Pickering Units 1 and 2 Retubing and Upgrading Program

During the recent retubing outages (1983 - 1988) of Pickering Nuclear Generating Station Units 1 and 2, a major inspection and upgrading program was carried out with the following objectives:

(1) To determine the extent of age-related degradation and the condition of many of the plant critical and other safety-related components.

(2) To upgrade deteriorated components to current standards.

(3) To help formulate future inspection and maintenance programs consistent with the NPLA objectives.

In addition to the above objectives, an upgrading program was also performed to bring a number of plant systems to standards inherent in the more recently built CANDU units. In this sense, the retubing and upgrading program at Units 1 and 2 can be considered a major step in the life assurance activities.

Because of schedule and resource constraints, it was not possible to inspect all critical components included in Table 2. The results of these inspections, as applied to the Ontario Hydro nuclear plant life assurance criteria show that most of the critical components inspected are in good condition, and preventive maintenance programs are effective in maintaining a negligible degradation rate of component materials. However, based on the inspection results and the recommissioning performance tests, it is expected that the units will achieve the nominal service life of 40 years, and there is every reason to believe that the option of extending the life beyond 40 years is a practical proposition.

5.2 Pickering Units 3 and 4 Retubing and Upgrading Program

The pressures tubes at Pickering Units 3 and 4 and other nuclear units of OH are made from Zr-Nb material as compared to the Zircaloy-2 material in Pickering Units 1 and 2, and they are expected to be less susceptible to degradation due to a lower rate of deutrium pickup. Recent inspections at Pickering Unit 3, however, have shown one pressure tube to have higher than expected level of deutrium. More data are being collected to determine whether this is a generic problem with Zr-Nb pressure tubes. In the meantime, in spite of insufficient data but because of the manpower, man-rem, retubing outage schedules for all nuclear units, and system considerations, OH has decided to retube Pickering Units 3 and 4 starting in 1989 and 1991 respectively. During this retubing program, critical component condition assessment and upgrading, if appropriate, will be performed. These programs will take into account more fully the objectives of the NPLA program than was possible during similar programs for Pickering Units 1 and 2.

6. AGING STUDIES USING COMPONENTS FROM DECOMMISSIONED NPPs

An important part of the programs related to understanding the aging characteristics of NPP components and the development of effective detection and mitigation methods is the examination and testing of naturally aged plant components and materials. Thus, systematic NPP component aging studies have been initiated using components from decommissioned plants at NPD and Douglas Point.

6.1 NPD Station: Acquisition and Testing of Naturally Aged Components and Materials

After 25 years of operation, the NPD nuclear station was permanently shut down and decommissioned. This offered an excellent opportunity to obtain samples of naturally aged plant components and materials. Since plant components at NPD had been exposed to their operating environment longer than any other CANDU plant, it is believed that testing and examination of these components could help in identifying presently unknown aging mechanisms and thereby improve the long-term reliability and safety of OH's currently operating nuclear plants. This is in spite of some differences in design, materials, and operating conditions. Following the decision to decommission NPD two years ago, an R&D program utilizing selected NPD components was prepared by a working group composed of representatives of the owner - Atomic Energy of Canada Ltd. (AECL), the operator - Ontario Hydro, and the regulator - Atomic Energy Control Board (AECB). The program which is in two stages, is being carried out by Ontario Hydro and AECL staff, and is co-sponsored by OH, AECL, AECB and EPRI.

A methodology was developed to select from the hundreds of plant components and materials those that would have the greatest applicability to current CANDU nuclear plants. Selected components included pressure tubes, samples of large bore PHT piping, concrete samples, cable samples, motors, and in-situ tests on generator, motors, and electrical circuits. The objectives of the proposed programs related to the NPD components and materials are as follows:

(1) To provide information for OH's NPLA program by providing important general perspective on the aging characteristics of nuclear plant equipment and to improve our understanding of the long-term safety, reliability and maintainability of operating CANDU power stations through investigations of potential degradation mechanisms and failure modes.

(2) To identify presently unrecognized (unknown) synergistic aging mechanisms that could have a significant impact on the long-term safety and reliability of operating nuclear power plants.

(3) To help resolve several generic issues of concern to OH, and the regulatory agencies. Examples of such issues include the validation of accelerated aging and remaining life prediction models, and the development of condition monitoring techniques.

The Phase 1 work at NPD related to the retrieval of components and materials and the conduct of in-situ tests is now complete. Phase 2 work covers actual laboratory investigations of these naturally aged components and material samples. The scope of this work is presently being defined by project leaders with input from design, operations, research, and regulatory staff. Full details of the scope, benefits, and relevancy of work at NPD appear in reference [8].

6.2 Douglas Point Station: Acquisition and Testing of Naturally Aged Components and Materials

A program of acquiring naturally aged components and materials, and of conducting in-situ tests has recently been initiated at the Douglas Point station. Full details of the proposed program will be available shortly.

7. EQUIPMENT QUALIFICATION

The role of equipment qualification (EQ) in managing aging and maintaining operational readiness of essential safety equipment is well known. So is the evolution of EQ during the 70's and 80's which resulted in different degrees of EQ in plants of diffferent ages. In Canada, new plants such as the Darlington nuclear station have a comprehensive EQ program which accounts for aging degradation through the concept of qualified life. The qualified life of selected equipment is established in the pre-operational stage and then monitored and maintained by appropriate operational and maintenance measures during the operational stage. Earlier plants have a program to maintain the initial degree of qualification, consisting of scheduled testing, inspection, maintenance, replacement and staff training activities. As well, status of EQ at these plants is being reviewed and upgraded on a selected basis. In particular, steps are being taken to protect existing safety-related equipment against harsh accident environment (e.g. moisture and submersion) where possible, or to replace it with equipment qualified for the expected service environment.

In addition to the above efforts by plant operators to maintain and improve EQ, there is a need to prepare and issue a planned CSA standard on EQ which would facilitate the implementation of EQ to generally accepted standards. A recently published AECB report [9] provides an overview of current EQ issues and practices, including recommendations on EQ standards and requirements.

8. RESEARCH AND DEVELOPMENT

Although progress has been made towards understanding and managing aging degradation of NPP components there are still many issues not fully understood which require appropriate R&D support. In Canada in recent years, both the nuclear industry and the AECB have approached NPP aging in a proactive way as illustrated by the above examples.

At present, R&D efforts are underway or are planned in the following areas:

- understanding of various material and component degradation mechanisms (e.g. for elastomers, different pressure boundary components and electrical cable insulation);
- development and validation of component remaining life prediction models (e.g. for pressure tubes and steam generator tubes);
- validation of accelerated aging techniques using naturally aged samples of NPP components (e.g. electrical cable insulation);
- development of in-situ repair technology for power plant components (e.g. for various pressure retaining components);
- development of improved non-destructive examination techniques;

- development of diagnostic and condition monitoring techniques for selected plant components (e.g. for electrical insulation of motor and generator windings and for various rotating equipment); and

- development of contingency plans for full scale replacement of major plant components (e.g. steam generators).

The results of this work are documented in numerous reports. We believe that a strong R&D program is a very important element of aging management. R&D can not only resolve specific problems, but can also discover new, emerging problems not yet observed in the operating plants. In addition, good research creates knowledge and competence which enables resolving unanticipated problems as they arise.

To continue receiving, and to maximize, these benefits of R&D, cooperative research projects and programs between Canadian nuclear industry, the AECB, foreign and international organizations should continue and be further developed.

9. IAEA NPP AGING PROGRAM PARTICIPATION

IAEA commenced activities concerned with safety aspects of NPP aging in 1985 when it convened its first working group on this subject. Canada joined these activities the following year at the Technical Committee Meeting which brought together representatives of eleven Member States and the Nuclear Energy Agency of OECD. Since then, Canada has been one of the more active participants.

In the early activities, which were oriented towards the safety aspects of NPP aging, Canadian contributions included, among others, participation in the Working Group which drafted a state-of-the-art report on safety aspects of NPP aging (to be published by the IAEA), and chairing of the Advisory group which in June 1988 prepared and recommended to the IAEA a multi-year program "Nuclear Power Plant Aging: Safety Aspects and Life Extension". The main objectives of this program are to establish and maintain, under the auspices of the IAEA, a program of international cooperation and information exchange with the purpose of understanding aging degradation processes and of developing methods and guidelines to manage aging. More details about the program can be found in reference [10].

More recently, Canada has provided the chairman for the two consultants meeting (December 1988 and April 1989) organized by the IAEA's Division of Nuclear Power on the general topic of "Nuclear Power Plant Aging and Life Management", and at the Agency's request, will be providing a cost-free expert to manage the 1989 activities sponsored by the Division of Nuclear Safety. As can be seen from the above, over the last three years, Canadian participation in and contribution to the IAEA program on NPP aging and life management have been substantial. It should be recognized that at the same time the relevant Canadian programs discussed in this paper have also benefited significantly from this participation. To stay abreast of new developments, we should continue to contribute to and benefit from this IAEA program.

10. REGULATORY POLICY DEVELOPMENT

The general safety concern related to the aging of NPP components is that plant safety could be impaired if the degradation of key components and structures is not detected and timely corrective action not taken before loss of safety function occurs. In particular, it is possible that degradation may not be revealed during routine operation and availability testing, but may

lead to erosion of defence-in-depth and failure or even multiple failures of redundant components under transient conditions associated with an operational upset or accident when the safety function is suddenly demanded.

The AECB recognizes and acknowledges that the Canadian nuclear industry has initiated and continues to develop the programs to manage both the safety and reliability aspects of NPP aging, as described in the previous sections of the paper. At the same time, the AECB believes that, as the first CANDU commercial plants approach the midpoint of their nominal service life, it is timely to document a regulatory policy on safety aspects of NPP aging. Consistent with the goal of the Canadian programs on NPP aging described in Section 2, the goal of the AECB regulatory policy will be to enhance the existing measures for maintaining plant safety during the entire and, especially, the later years of plant service life.

An internal AECB consultation process on development of the policy document is underway. It includes considerations of Canadian, foreign and international studies and experience on safety aspects of plant aging. According to standard AECB procedure, the policy proposal will be published as a Consultative Document to obtain comments both from the nuclear industry and the general public. These comments will be then considered by the AECB before releasing the policy in final form.

11. CONCLUSIONS

The Canadian nuclear industry and the AECB recognize that aging is an important area of concern, and that reliability of NPP components, and consequently the overall plant safety and reliability may decline during the middle and later years of plant life. To control and manage the negative effects of aging, a number of proactive programs have been initiated. Much remains to be done to understand the known and potential new aging processes, and to develop effective methods for their timely detection and mitigation.

Continued improvement of the individual programs, taking better advantage of relevant experience from other industries, and strong commitment and cooperation of all involved organizations at the national as well as at the international levels will ensure the safe and reliable operation of NPPs through their entire service life.

REFERENCES

[1] Novak, S., and Podest, M., *"Safety Aspects of NPP Aging and Other IAEA Activities Related to Plant Life Extension"*, Proc. 1987 NEA Symposium on Nuclear Power Plant Life Extension, OECD, Paris, pp. 64-72.

[2] Sidey, D., et al., *"Metallurgical Aspects of Life Assessment of Coal-Fired Power Plants"*, Presented at the International Conference on Life Assessment and Extension, June 13-15, 1988, The Haig, Netherlands.

[3] Pachner, J., *"Detection and Mitigation of Aging and Service Wear Effects of Nuclear Power Plant Components in Canada"*, Proc. 1987 Int. Symp. on Safety Aspects of the Aging and Maintenance of NPPs, IAEA, Vienna, 1988, pp. 109-120.

[4] Chadha, J.A., Daly, I.N., *"Status of the Nuclear Plant Life Assurance (NPLA) Program for Ontario Hydro's Nuclear Generating Stations"*, International Conference on Availability Improvements in Nuclear Power Plants, Madrid, Spain, April 10-14, 1989.

[5] Chadha, J.A., Daly, I.N., *"Nuclear Plant Life Assurance (NPLA) Program for Ontario Hydro's Nuclear Generating Stations"*, Proceedings of the Topical Meeting on Nuclear Power Plant Life Extension, Snowbird, Utah, August 1988.

[6] Novak, S., *"Preliminary Study of NPP Life Extension Effectiveness in a Country Extending Electricity Production Exclusively on Nuclear Power Plant Production"*, Proc. 1987 NEA Symposium on Nuclear Power Plant Life Extension, OECD, Paris, 1987, pp. 48-58.

[7] Forest, L.R., Jr., et al., *"Cost Savings from Extended Life Nuclear Plants"*, Proceedings of the Topical Meeting on Nuclear Power Plant Life Extension, Snowbird, Utah, August 1988, pp. 225-231.

[8] Chadha, J.A., et al., *"NPD Station Decommissioning: Nuclear Plant Aging Studies Using Naturally Aged Components and Materials"*, Report No. 88-253-K, Ontario Hydro Research Division, 1988.

[9] Torr, K.G., *"Overview of Nuclear Power Plant Equipment Qualification Issues and Practices"*, INFO-0296, AECB, 1989.

[10] Pachner, J., and Novak, S., *"Proposed IAEA Programme on Safety Aspects of Nuclear Power Plant Aging and Life Extension"*, Proc. 1988 Int'l NPP Aging Symposium, US NRC, Washington, D.C., 1989, pp. 39-41.