CANDU STEAM GENERATOR AGING MANAGEMENT: SOME PERSPECTIVES AFTER 20 YEARS’ IN-SERVICE EXPERIENCE

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AECL, in collaboration with a number of utilities, has carried out several steam generator (SG) condition assessments with the objective to assure reliable remaining life and to provide a prognosis for extended life capability. With in-service dates ranging from 1972 to 1983, and a variety of tubing materials, the condition assessments have identified a wide range of challenges for an effective SG aging management program. All of these SG condition assessments were carried out in conjunction with overall plant condition assessments, performed either by AECL, the utility, or both in partnership.

Significant factors found to limit SG life and to challenge aging management, are identification of critical degradation mechanisms for each of the key structural materials, evaluation and determination of the life limiting sub-components, the need to develop improved inspection technology and plans that track the life limiting components, the need to create and use databases of plant information (in particular that from commissioning) and the development of recommendations for future operation and maintenance.

Effective condition assessment and aging management (AM) requires a co-ordinated application of research and development (R&D) knowledge, plant or component design, and a thorough understanding of the operational history and the current plant programs including monitoring, inspection and maintenance related to aging. In fact, the R&D program at AECL has been restructured to provide tools and databases for condition assessment and AM. An example is the use of our knowledge of component design and function and system chemistry to interpret eddy current data obtained from SG tubing and predict primary side fouling behaviour. That knowledge, coupled with our understanding of heat transport and nuclear steam supply systems performance provides input not only for current condition assessment, but also for planning of remedial actions.

Several Canadian CANDU units have been placed in lay-up whilst condition assessments and rehabilitation programs are carried out. These rehabilitations, although costly, are justified economically. The economics require careful evaluation of current condition and, especially challenging, of remaining life. Review of the current condition of the SGs that have been laid up demonstrates the importance of layup chemistry control practices, and the variability introduced by the different tube materials. Questions arising from the layup condition, and its impact on future life, are difficult to address quantitatively. Further R&D is required to define the linkage between layup condition and future aging degradation.

At CANDU 6 plants, there has been an excellent steam generator service record with little or no significant active degradation to date and several of the utilities are actively pursuing the option of planning for extended operation. At three of the older CANDU 6 plants, detailed and comprehensive life assessment studies of the steam generating equipment, the interfacing systems, the external support structure, the tubing, and all the key internal sub-components, has been completed. The studies involved a very thorough assessment of tubing corrosion mechanisms that can occur in various forms in nuclear steam generators. CANDU-6 SGs are

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tubed with Alloy 800M (M means “modified”) and have experienced relatively little SG tube corrosion to date.

Despite this excellent record, it is well known that steam generators provide challenges for the assurance of continued on-going good health, as operation continues through to design life and particularly for a significant period of extended operation beyond. While the prognosis for life attainment and for extended operation of CANDU 6 Steam Generators is good, it has also been found that this conclusion is very dependent upon implementation of the recommended program enhancements of inspections, maintenance, chemistry control and assessment of the future field data. Subtle changes to plant operation and also the unique plant-specific details of materials and design often can have a significant impact on the life capability of this complicated equipment. From the plant-specific assessments, and from the experience from our R&D program and utility interaction, AECL has developed a detailed proactive SG aging management strategy for long and reliable life capability (to 50 years). This proactive strategy has a number of important elements that are recommended to be incorporated into current plant programs.

With CANDU plants continuing operation with aging equipment, such as steam generators, AECL is continuing to undertake comprehensive programs to support operations and provide enhanced technologies for performance attainment and improvement in inspection, surveillance and performance/safety analysis methodologies. These technologies are also continuously improved by programs that are targeted to important in-service degradation mechanisms, understanding of the system/equipment tolerance to this degradation, and to measures that can be applied to both new reactors and back fitted to existing plants. Systematic and continuous feedback of experience from operations to the performance programs is another important part of the approach.

This paper will outline the results of several CANDU SG condition assessments, and place the recommendations from these assessments in context with effective Aging Management programs that need to be followed to achieve economic life. For CANDU 6 utilities, which have had a very good steam generator service record with little or no significant active degradation to date, the paper will outline the approach to proactive Aging Management that will see equipment through to long and reliable extended life. Also mentioned will be examples of AECL performance improvement and operations support programs for steam generators.