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Subject: **Response to NRC Inspection Report 50-293/94-01**

This letter responds to the subject inspection report and provides additional information regarding Pilgrim's fatigue life monitoring program.

Pilgrim's reactor vessel and components are within design limits.

As the inspection report states, we have retained records of transients and operating cycles consistent with Technical Specification Section 6.10.B.7. Review and analysis of the records provide assurance that the primary system components and piping remain within the Updated Final Safety Analysis Report design bases.

These actions have been effective and enabled us to identify that it is time to update the original fatigue analysis to reflect operation to-date and more accurately predict cumulative usage factors for the 40 year licensed lifetime.

We identified the need for an updated analysis several months before the inspection was announced. A contract was awarded in August 1993 to perform a new analysis and the effort was well underway at the time of the inspection. The preliminary results show that even with conservative counting, component fatigue life is at least several times what was estimated in the original analysis. For example, for the feedwater nozzles the previously predicted cumulative usage factor of 0.97 will now become about 0.2.

Please feel free to contact me if there are any questions regarding this subject.

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BACKGROUND

Pilgrim was originally designed considering fatigue. Fatigue analysis of the reactor vessel and components was performed in 1971 by Combustion Engineering, the reactor vessel manufacturer.

Technical Specification 6.10.B.7 requires lifetime retention of records of transients or operating cycles for those facility components designed for a limited number of transients or cycles. Our program for records retention has been in place since initial operation.

Last year, we decided to perform a new fatigue analysis because we were near the end of the second 10 year inspection interval and certain events/cycles were approaching the number assumed for the 40 year license lifetime at a faster rate than was anticipated. We were also about half way through the 40 year license lifetime and noticed that actual transients and design basis cycles did not readily relate to each other.

Meanwhile, continued operation is justified because overly conservative assumptions and calculations were used in the original fatigue analysis, and re-analysis to-date indicates that component fatigue is several times lower than estimated in the original analysis.

SUMMARY OF THE NRC INSPECTION REPORT

In January 1994, our program for fatigue monitoring was inspected. Inspection Report 94-01 documents the inspection and findings.

The inspection confirmed that:

- We are meeting records retention requirements of transients or operational cycles for those components designed for a limited number of transients or cycles as required by Technical Specification 6.10.B.7.

- We have a comprehensive set of procedures for monitoring plant performance.

- We have a Quality Assurance Program in effect for audit and surveillance of records retention.

- We have used a conservative definition for counting events as transients or operational cycles.

The inspection report however, identified or inferred several questions or concerns. Specifically:

- On the first page of the transmittal letter:"... the number of cycles expended to-date of some transients exceeds the number of transient cycles for which the plant components have been designed."

- Also on the first page of the transmittal letter: "...for other transients... continuing at the same rate of occurrence will exhaust the design cycles prior to the 40 year design lifetime of the plant."

- In section 2.1.1 second paragraph last sentence: "Operation beyond the specified number of cycles is outside the design basis described in the UFSAR".

- Section 2.1.5 third paragraph: "... the inspector found that, for the design transients predicted over the 40 year licensed lifetime, the level of cumulative usage factors at several critical regions of the reactor vessel warrants concern, in light of the fact that some of the applied numbers of transients have already exceeded the level for which the components have been designed."

These statements in the inspection report have led to some confusion of this subject. The DISCUSSION section provides additional information that more fully explains fatigue life and basis for concluding the reactor vessel and components are within design limits.

<u>DISCUSSION</u>

Pilgrim is about midway through its operating life (in chronological years) which is a reasonable time frame to reassess the fatigue life of the plant. This is being done. The NRC inspection report includes a review of the efforts currently being undertaken to assess fatigue life of the reactor vessel and components. Statements made in the inspection report, in fact, are an endorsement of this program. The report noted that BECo has taken the initiative to re-analyze the reactor vessel and also noted the number of cyclic events are overly conservative estimates of the true number of stress cycles which contribute to fatigue.

Last year, BECo decided to re-analyze the reactor vessel to provide a more accurate determination of cyclic stress levels and develop more realistic transient effects (cyclic load combinations). The new analysis was implemented on our own initiative approximately five months prior to notification of the NRC inspection and six months prior to the actual inspection. The analysis is scheduled for completion in July 1994. This analysis is being performed by a local consulting firm (Altran Corporation, Boston, MA). Based on engineering experience and judgment, the improvements realized from this analysis will significantly increase the number of cycles allowed over the number of cycles used for the original fatigue assessment. Preliminary analysis results indicate that the number of cycles can be significantly increased.

The original structural and fatigue analysis of the reactor vessel and components is now over 30 years old. The original analysis was based on simplifying assumptions and manual calculations. Since plant operating histories were nonexistent at that time, these vintage calculations "anticipated" service conditions (cycles) and presumed these conditions act and combine in an unrealistic "worst case" manner. Consequently, significant conservatisms were built into both the application of the "postulated" service conditions (cycles) and the analytical methods used to determine the structural integrity associated with fatigue life of the vessel and components. Nevertheless, there was sufficient margin between the calculated fatigue usage factors and the design basis limit.

The subsequent evolution of computer technology and the resulting application of state-of-the art techniques such as finite element and transient time history analyses are major advancements which made the original calculations and analysis obsolete. Therefore, a new analysis was initiated. Overly conservative assumptions can be removed and calculations modified. The fatigue life of a given component can be extended relative to the fatigue life expected from the original analysis because the transient conditions can be more accurately described and the structural behavior of components under varying loading conditions better understood.

A listing of events, not cycles, was provided to the NRC Inspector during the inspection. The listing of events was provided because the development of our program including assignment of events to cycles (when appropriate) has not been completed. The tabulated numbers identified in the inspection report section 2.1.4 as cycles-to-date (21 years) and projected cycles (40 years) are the listing of General Electric SIL 318 counted events provided to the NRC Inspector. The counting of events, not necessarily cycles, was conservative. A cycle corresponds to a particular event but any event does not necessarily correspond to a cycle which contributes to fatigue. The difference between cycles and events is important because cycles can contribute to fatigue while events may not.

For illustrative purposes, examples of conservative event counting include:

Startup events. Events counted were startups from zero reactor power, regardless of the completion of a startup and regardless of reactor conditions (power, pressure and temperature).

Power increase events. Events counted were startups up to turbine-generator synchronization to the switchyard, regardless of subsequent power increase and reactor conditions.

Loss of feedwater pump events. Events counted included: low reactor water due to feedwater pump or feedwater regulating valve problems, regardless of reactor conditions; or low reactor water level due to loss of preferred (345 kv) offsite power, regardless of reactor conditions; or MSIV isolation resulting in appreciable increase in reactor vessel pressure.

Safety Relief Valve (SRV) blowdown events. Events counted were unplanned or planned opening of a SRV(s) regardless of effect upon the reactor vessel. Events included: reactor vessel depressurization (full or partial) resulting from unplanned SRV opening due to SRV failure/malfunction; unplanned opening (momentary) of an SRV(s) for pressure relief; unplanned/planned opening (momentary) of an SRV(s) for reactor pressure control; planned opening of an SRV for post work testing; or planned opening (momentary) of an SRV(s) during startup per NUREG-0737.

The inspection report listing of accumulated cycles for 21 years and extrapolated to 40 years is conservative because the listing is based on SIL 318 counted events. The previously discussed methodology for SIL 318 event counting was conservative and in many instances events were counted regardless of the effect upon the reactor vessel. Therefore, the inspection report identification and tabulation of SIL 318 events as cycles is conservative relative to the number of cycles actually experienced. Moreover, the expected number of cycles from now to the end of life are much less than the projected cycles (40 years) identified in the inspection report. Specifically, the projected number assumed a linear relationship from the first 21 years of operation that included a relatively large number during initial startup, early years of operation, and during the power ascension program from RFO 7. In other words, events decrease over time. We believe this explanation clarifies the difference between events counted for SIL 318 and the inspection report identification and tabulation of the events as cycles for 21 years and 40 years.

The inspection report also discusses some cumulative usage factors (CUFs) from the Reactor Vessel Report (CENC 1139) and the Updated Final Safety Analysis Report (UFSAR). The CUFs in CENC 1139 and the UFSAR were calculated using simplifying assumptions and calculation methods required and allowed by the ASME Code. The CUFs are based on ASME Code fatigue curves. The procedure for analysis of cyclic loading and CUF for a component is currently described in ASME Section III (1986) article NB3222.4(e). For a given component, the cumulative usage factor "U" for each stress cycle is equal to the sum of the individual usage factors. In equation form,

$$U_n = {}^{n}n/N_n, \text{ or } U = U_1 + U_2 + \ldots U_n$$

Where n = the number of design cycles
N = the number of cycles from the ASME fatigue curve.

Calculations and analyses have been performed which demonstrate the CUFs for the components listed in CENC 1139 and UFSAR are less than the design limit of 1.0. The components include those for which the number of SIL 318 counted events are greater than the number of design cycles for 40 years. For all components the CUFs were and are less than 1.0. In particular, the CUFs for the Recirculation Inlet Nozzles and Outlet Nozzles are less than 0.1 and 0.2, respectively - a significant improvement. Moreover, the CUFs for the Feedwater Nozzles are less than 0.2 - also a significant improvement. These recirculation and feedwater nozzles are mentioned in particular because the CUFs for these components was relatively high (CENC 1139 and USFAR).

In addition to the analysis being performed, BECo is developing a comprehensive program to study and evaluate the original methods and assumptions used to determine fatigue life. The plant has been in operation since 1972 and the knowledge gained since 1972 allows for more accurate predictions of future operating conditions. This program is being formally developed by Pilgrim Station personnel. Preliminary results of the on-going analysis show that, even with the conservative counting reported in the inspection report, component fatigue life is at least several times greater than that estimated 30 years ago.

CONCLUSIONS

The reactor vessel and components are within design limits.

We have a comprehensive set of procedures for documenting and monitoring plant performance.

The fatigue life to-date is much less than the fatigue life projected during the original analysis and implied by the data in the inspection report.

The projected number of cycles from the present to the end of life will not result in cumulative usage factors greater than 1.0.