SOUTHERN CALIFORNIA
EDISON
An EDISON INTERNATIONAL℠ Company

J. L. Rainsberry
Manager, Plant Licensing

September 18, 1998

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington D.C. 20555

Gentlemen:

Subject: **Docket Nos. 50-361 and 50-362**
Response to Request for Additional Information Regarding
Amendment Applications 178 and 164
Turbine Missile Protection
San Onofre Nuclear Generating Station, Units 2 and 3

References: 1) Letter dated September 10, 1998, from James W. Clifford (NRC) to Harold B. Ray (SCE), Subject: Request for Additional Information Related to License Amendment Request for Turbine Missile Protection, PCN-494 (TAC Nos. MA2186 and MA2187).

2) Letter dated June 12, 1998, from D. E. Nunn (SCE) to Document Control Desk (NRC), Subject: Docket Nos. 50-361 and 50-362, Amendment Application Nos. 178 and 164, Turbine Missile Protection, San Onofre Nuclear Generating Station Units 2 and 3

Provided as Enclosures 1, 3, and 4 is a response to an NRC request for additional information (Reference 1) regarding Southern California Edison's (SCE's) license Amendment Applications 178 and 164 (Reference 2) for the San Onofre Nuclear Generating Station, Units 2 and 3. These amendment applications requested a change in methodology for evaluating the acceptability of Turbine Missile Protection. The proposed change supports the turbine retrofit project, currently planned for the Units 2 and 3 Cycle 10 refueling Outages, which are scheduled to begin in January 1999.

Amendment Applications 178 and 164 were based in part on an analysis of missile generation probability provided by the turbine vendor, Alstom. The questions provided in Reference 1 dealt mainly with the design of the new rotor as an input to the San Onofre Retrofit Missile Analysis Report. The missile analysis report was provided as Enclosure 2 of Reference 2.

A001

San Onofre Nuclear Generating Station
P. O. Box 128
San Clemente, CA 92674-0128
714-368-7420

Enclosure 1 to this letter provides specific answers to each of the five NRC questions posed in Reference 1. Some of these responses are excerpted from, and reference, a more general discussion of the turbine provided as a report from the turbine rotor vendor Alstom in Enclosure 3.

Because Enclosure 3 contains proprietary information owned by Alstom, in accordance with the requirements of 10 CFR 2.790(a)(1)(i)(4), SCE requests that the contents of Enclosure 3 be withheld from public disclosure because they contain information pertinent to trade secrets and commercial or financial information considered to be privileged or confidential. In accordance with the requirements of 10 CFR 2.790(b)(1), the required affidavit supporting this request is provided as Enclosure 2. A non-proprietary version of the report is provided in Enclosure 4.

In addition, the San Onofre Retrofit Missile Analysis Report contained in Enclosure 2 of Reference 2 also is proprietary information owned by Alstom. Therefore, in accordance with the requirements of 10 CFR 2.790(a)(1)(i)(4), SCE requests that the contents of Enclosure 2 of Reference 2 be withheld from public disclosure because they contain information pertinent to trade secrets and commercial or financial information considered to be privileged or confidential. The affidavit in Enclosure 2 encompasses Enclosure 2 of Reference 2 as well as the information in Enclosure 3 to this letter. A non-proprietary version of Reference 2 will be submitted as soon as it is available.

To support the requested approval date of December 1, 1998, SCE also requests a meeting with the NRC to discuss the information provided in the enclosure and answer any additional questions which may arise.

If you have any additional questions on this subject, please call me.

Sincerely,

J. L. Rainsberry
Manager,
Plant Licensing

Enclosures

cc: E. W. Merschoff, Regional Administrator, NRC Region IV
J. A. Sloan, NRC Senior Resident Inspector, San Onofre Units 2 & 3
J. W. Clifford, NRC Project Manager, San Onofre Units 2 and 3

ENCLOSURE 1

RESPONSES TO NRC QUESTIONS

San Onofre Nuclear Generating Station
Units 2 and 3
Low Pressure Turbine Rotor Replacement

INTRODUCTION

This document is in response to the NRC's request for additional information in letter dated September 10, 1998 from Mr. James W. Clifford, Senior Project Manager to Mr. Harold B. Ray, Executive Vice President, SCE.

The information provided in this document is in support of San Onofre Nuclear Generating Station (SONGS) Amendment Application Nos. 178 and 164 which consist of Proposed Change Number 494 (PCN 494), which is a request to revise the licensing basis as described in the Updated Final Safety Analysis Report (UFSAR) Section 3.5, "Missile Protection". The proposed change supports the turbine retrofit project, currently planned for Units 2 and 3 Cycle 10 refueling outages which are scheduled to begin in January 1999.

Responses to the five questions from the NRC letter dated September 10, 1998 are provided below. Some of these responses are excerpted from, and reference, a more general discussion of the turbine provided as a report from the turbine rotor vendor Alstom in Enclosures 3 (proprietary version) and 4 (non-proprietary version).

Question 1

Please provide the operating experience with the proposed new welded design turbine rotor. How many of those rotors are currently in service? Where and how long have the rotors been in service?

Answer

ALSTOM is the largest single supplier of nuclear steam turbines in the world, having supplied more than 20% of the world market. The entire French nuclear program uses exclusively ALSTOM steam turbines, up to and including the largest half speed units in the world - four 1530 MW, 1500 r/min units at Chooz B and Civaux. ALSTOM is the leading exporter of nuclear steam turbines into China and has supplied two 985 MW, 3000 rev/min units for Daya Bay in China with a further two units on order for Ling Ao. These turbines are some of the largest full speed nuclear units in the world.

The replacement LP turbine rotors for San Onofre Units 2 & 3 utilize the well proven ALSTOM welded rotor technology. This technology has been used since the 1950's in fossil units and has been applied in operational nuclear turbines since 1981. To date, 119 welded LP rotors have been supplied for nuclear steam turbines operating with PWR steam conditions. These turbines include the 1530 MW units at Chooz B and Civaux in France, together with the recent nuclear LP retrofits at Tihange and Doel in Belgium.

The largest welded LP rotors supplied by ALSTOM are those in the Chooz B and Civaux units, which weigh 365,000 lbs when fully bladed. The rotor length is 39 feet 3 inches, and the last stage blades are 57 inches long with a tip diameter of 18 feet 4 inches. For comparison, the replacement San Onofre LP rotors weigh 312,000 lbs., are 35 feet 5.7 inches long with last stage blades 47.25 inches long and a tip diameter of 15 feet 2.5 inches.

Some of these units have accumulated more than 100,000 operating hours (see Enclosures 3 and 4, table 1), and Stress Corrosion Cracking (SCC) has never been found on any of these nuclear steam turbine welded rotors. The 6 replacement LP rotors for San Onofre take advantage of this extensive and successful operating experience.

Optiflow LP turbines have been widely applied by ALSTOM over many years, (see Enclosures 3 and 4, table 2) and extensive operating experience has been accumulated with many of these units. In particular, the LP retrofit of the 2x500 MW PWR nuclear units at Tihange, Belgium uses optiflow LP turbines. In the USA, the 285 MW Dupont Chambers plant in New Jersey has an optiflow LP turbine.

Question 2

What is the material specification for the rotor (i.e., ASTM specification)? What is the specified minimum and maximum yield strength for the rotor material? What is the minimum specified fracture toughness of the material?

Answer

This information is considered proprietary. For details see ALSTOM Energy Ltd. Report "San Onofre 2 & 3 Replacement LP Rotors" dated 17 September 1998, and the Missile Analysis Report submitted as Enclosure 2 to PCN 494. Yield strengths are presented in Tables 3 and 4 of Enclosure 3. The maximum Fracture Appearance Transition Temperature (FATT) is presented in Table 3 of Enclosure 3. The corresponding range of fracture toughness values is presented in Figure 29 of the Missile Analysis Report.

Question 3

The June 12, 1998, submittal indicates that the center of the rotor will not be bored to remove impurities and facilitate future UT examinations. Please provide the basis for this decision.

Answer

It has been ALSTOM policy for many years to take delivery of forgings in the unbored condition from suppliers with a proven (qualified) manufacturing process, and it is a policy consistent with that of other Original Equipment Manufacturers (OEMs). A qualified manufacturing process is one which is demonstrated to produce the required material properties, including tensile strength and FATT, throughout the volume of the forging. Qualification of a manufacturing process requires that a number of production forgings are bored to establish that the required properties are achieved in material removed from the forging centerline. Following qualification of a supplier's process, subsequent forgings are supplied in the unbored condition. The achievement of specified properties at sampling positions towards the periphery of the forging coupled with the close control of the qualified forging process guarantees that the required properties are obtained throughout the forging.

Modern rotor forgings are produced by leading edge technology steelmaking methods, utilizing optimized ingot designs which minimize the segregation of impurities during the solidification process. Adequate discarding of ingot ends removes the segregated zones from the usable part of the ingot. The forging methods employed give full consolidation of the ingot and eliminate center-line porosity. This, together with uniform heat treatment, results in uniform mechanical properties and low ultrasonic attenuation characteristics. The ultrasonic test methods applied to large unbored forgings reliably detect defects which are well below the small sizes permitted by the Alstom NDT acceptance standard. It is therefore unnecessary to bore forgings to establish that they are free from unacceptable defects.

The potential for repeated application of centrifugal and thermal loading during unit start-up and shut-down to cause pre-existing defects within the rotor forging to extend to a size which could cause brittle fracture has been investigated. Defect growth during 500 start-up shut-down cycles has been conservatively assessed assuming initial defect sizes which are much larger than the maximum ultrasonic indication sizes permitted by the defect acceptance standard applied to the rotor forgings, and fatigue crack growth rates which are higher than the upper bound of the available data. The resulting fatigue extended defect sizes at end of service were compared to the minimum critical crack size for brittle fracture during overspeed assuming minimum expected material fracture toughness. The margins between maximum fatigue extended defect size and minimum critical defect size are large since the growth of defects in service is calculated to be very small and the minimum critical defect sizes are relatively large, as described in the Missile Analysis Report.

For the above reasons it is unnecessary to bore rotor forgings to establish that they are initially free from unacceptable defects or to confirm that they remain free from unacceptable defects after periods of service. In fact, it is not only unnecessary but is generally undesirable since an axial bore acts as a stress concentrating feature, increasing the stress at the center of the rotor by a factor of two compared to the unbored condition.

Question 4

The June 12, 1998, submittal is not sufficiently clear as to the scope of the turbine retrofit project. Will the control system be modified? Will the turbine valve testing be modified? The submittal indicates that a ten year turbine inspection interval and monthly testing of the steam valves supports the total annual probability of failure at any speed of 1 x 10^{-6} per unit year. Is SONGS committed to perform these inspections and tests at these intervals?

Answer

No changes to the turbine control systems are being made as part of the LP turbine replant project.

Currently the High Pressure (HP) and Low Pressure (LP) valves are tested on-line every month. The HP and/or LP valve test intervals are not being modified and the test method is not being changed.

However, it should be noted that Appendix 2 of the Missile Analysis documents the results of the probabilistic calculations with respect to the influence of LP Valve test intervals on probability of failure. The results demonstrate that should the LP valve testing intervals be increased to 6 months, the total annual probability of failure at any speed would still be less than 1 X 10^{-5} per unit year.

SCE does not intend to change the LP valve testing intervals at this time. However, based on operational experience, consideration may be given to increasing the LP valve testing interval in the future. The justification for such a change will be performed by using the 50.59 safety evaluation process, or the 50.90 license amendment process, as appropriate.

In addition to the above turbine valve testing, on-line testing of the overspeed trip, as shown in Appendix 2, is also factored in to the probability of failure. Currently, on-line testing of the overspeed trip system is performed quarterly. The overspeed trip system testing intervals are not being changed due to LP turbine replacement.

Appendix 2 of the June 12, 1998 Missile Analysis submittal includes probabilistic calculations of the influence of on-line overspeed test intervals on the probability of failure. The overall value of 1.7 x 10^{-6} for missile generation probability as reported in the Missile Analysis is based on case A (pages 22 and 23). This case assumed monthly testing of the HP and LP valves, as well as the overspeed trip. The actual case at San Onofre Units 2 and 3, monthly testing of the HP and LP valves and quarterly testing of the overspeed trip, is not one of the cases presented by the missile analysis. However, although not directly shown in Appendix 2, Alstom has performed the case of monthly on-line test intervals for the HP and LP valves concurrent with quarterly testing of the overspeed trip and has confirmed that there is no change to the overall probability of 1.7 X 10^{-6} as shown for case A.

Also, the only change from case B to case C (pages 22 and 23) is that of the overspeed test interval increasing from monthly to quarterly. The results demonstrate that the failure probabilities do not change as a result of the overspeed test interval increasing from monthly to quarterly.

Finally, it should be noted that even for a case of quarterly testing of the LP valves and quarterly testing of the overspeed system (case C), the missile analysis supports the total annual probability of failure at any speed of less than 1 X 10^{-5} per unit year.

Other Significant Changes Which Do Not Require Prior NRC Approval

Although not part of the LP turbine retrofit project, the following turbine system changes are expected to be implemented during the upcoming cycle 10 outage:

1. The High Pressure (HP) turbine stages 1, 2, and 3 diaphragms are being replaced with new diaphragms to improve HP turbine efficiency and plant performance. There is no change to the turbine valve controls.

2. The Condenser Low Vacuum Trip setting will be changed as a result of this modification. The current turbines have Condenser Low Vacuum Trip settings of 4.5"HgA for power levels less than 70% and 6.5"HgA for power levels above 70%.

   Due to the improved moving blades design, the new turbines will accommodate improved (increased) Low Vacuum Trip settings. Modification of the trip settings is planned for cycle 10 to take advantage of the higher allowable condenser back pressures. The new set points, listed below, will be controlled by a Programmable Logic Controller (PLC).

   Constant setting of 4.5"HgA for loads from 0 to 45%, linearly changed from 4.5"HgA at 45% load to 9.1"Hg at 100% load.

Question 5

Please provide a description of the welded rotor design and sketches for staff evaluation of the design. Include information that describes how the blades are attached to the disc. Include information that describes how the disc is attached to the rotor forging. Also identify the design improvements that are responsible for the 50% tangential stress reduction for the welded rotor.

Answer

The replacement LP rotors are of welded construction with the stages arranged in an 'optiflow' configuration, see figure 2 in Enclosures 3 and 4. The first four stages are single flow, enabling increased blade heights and reduced leakage to achieve optimum performance. After the first four stages the flow splits and continues through a further four stages arranged in conventional double flow.

Stages 1 - 6 moving blades are attached to the rotor using multi-finger pinned root fastenings and have torsion mounted integral shrouds in line with ALSTOM standard practice, see figure 3 in Enclosures 3 and 4. The long L-1 and L-0 blades are retained by axial entry root fastenings (straight for the L-1 and curved for the L-0). The L-0 blades, see figure 4 in Enclosures 3 and 4, are provided with continuous blade-blade interconnection in the form of integral 'snubbers' to control non-harmonic vibration such as the buffeting conditions which occur at high back pressures. The L-0 blade is 47.25" long (1200 mm).

The welded rotor consists of five relatively small forgings in 3% NiCrMoV welded together to form a single rotor. The use of a welded rotor gives the following benefits:

- Elimination of shrink fits and keyways.
- Low levels of tangential stress, see below.
- Use of lower strength material with consequent improved SCC resistance.
- Relatively small forgings, allowing high resolution during ultrasonic inspection.

For the welded rotor design, each forging piece comprises both the disc and shaft. Thus the disc and shaft are one integral piece. The welded rotor forgings carry centrifugal load much more efficiently than a shrunk-on disc rotor, in which the central shaft takes no part in carrying the centrifugal load of the blades and the disc itself but increases the disc stresses due to the shrink fit. In consequence, the tangential stresses in the welded rotor are reduced to about half the level of the shrunk-on discs of the original rotors, as illustrated for a typical stage in Figure 5, Enclosures 3 and 4.

ENCLOSURE 2

ALSTOM AFFIDAVIT

San Onofre Nuclear Generating Station
Units 2 and 3
Low Pressure Turbine Rotor Replacement

AFFIDAVIT

In the town of Rugby

and County of Warwickshire, England

I, Gary Furnival being duly sworn, hereby say and depose:

1. I am Project Manager with responsibility for the LP Turbine Retrofit of San Onofre Nuclear Generating Station for ALSTOM Energy Ltd (hereinafter referred to as ALSTOM) of Newbold Road, Rugby, Warwickshire, England.

2. I have read ALSTOM's reports entitled "San Onofre 2&3 - Replacement LP Rotors" dated 17th of September 1998 and "San Onofre Missile Analysis" hereinafter referred to as the Documents.

3. The Documents contain information of a proprietary and commercially sensitive nature which is regarded as strictly confidential by ALSTOM and shall not be released into the public domain. To the best of my knowledge and belief ALSTOM's competitor companies regard information of the kind contained in the Documents as proprietary and confidential.

4. We have made the Documents available, in confidence, to the US Nuclear Regulatory Commission, at the request of our customer Southern California Edison, with the request that the information contained in the Documents shall not be disclosed or divulged to third parties.

5. The information contained in the Documents reveals important aspects of ALSTOM's steam turbine design which has been developed through many years of extensive research and development activity giving ALSTOM steam turbines crucial enhancements over competitor's equipment sufficient to enable ALSTOM to maintain a

technical and commercial advantage over those of its competitors who are not in possession of the information contained in the Documents.

6. The disclosure of the proprietary information contained in the Documents to a competitor, not in possession of the information contained in the Documents, would result in substantial harm to the commercial interests of ALSTOM.

7. Information contained in the Documents has been made available, on a limited basis, to others outside of ALSTOM, only in accordance with strict conditions of confidentiality permitting its use for defined purposes and providing for nondisclosure to third parties.

8. ALSTOM require that such proprietary information released by ALSTOM to others should be kept in a secure file and not disclosed to third parties without the written consent of ALSTOM.

I hereby declare that the statements made hereinabove are, to the best of my knowledge, information and belief, truthful and complete

Signed [signature]

SWORD ~~SIGNED~~ before me

this 18th Day of September 1998
at 16, Church Street
Rugby

[signature]
(PAUL SMITH)
A Commissioner for Oaths

BRETHERTONS
16 CHURCH STREET
RUGBY
WARKS. CV21 3PW

BRETHERTONS
COMMISSIONERS FOR OATHS