GERRY E. STUDDS,
TENTH DISTRICT, MASSACHUSETTS

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March 1, 1994

Dennis Rathbun
Director, Office of Congressional Affairs
Nuclear Regulatory Commission
Washington
DC 20555

I am contacting you on behalf of my constituent, Ms. Mary Ott. Please see enclosed correspondence.

I would appreciate your attention to Ms. Ott's concerns, specifically the discrepancies between the attached memo and your response to my earlier inquiry on this matter. Please respond to me at: 1212 Hancock St, Quincy, MA 02169, Attn: Mary Lou Butler.

Sinceely,

Gerry E. Studds

Enclosure

Citizens Urging Responsible Energy

February 17, 1994

The Honorable Gerry E. Studds
United States House of Representatives
Washington, DC 20515-2110

Dear Congressman Studds:

In his February 1, 1994 letter to you on behalf of the Union of Concerned Scientists (UCS), nuclear safety expert Robert Pollard cites compelling new evidence that raises questions about the justification for continued operation of the Pilgrim Nuclear Power Station (PILGRIM) in Plymouth.

UCS cautions that a turbine failure at PILGRIM is not merely an economic concern for the Boston Edison Company, as the Nuclear Regulatory Commission (NRC) suggests, but "could result in a serious nuclear accident with significant radiological consequences for the public." These are sobering considerations for your constituents in Massachusetts and all New England as well.

We are writing to support UCS's request for additional analysis of the risks posed by PILGRIM's cracked turbine, to provide information refuting claims by Boston Edison, and to request an investigation to determine whether the NRC attempted to deceive you about the risks posed by continued operation of the PILGRIM plant.

The Christmas day turbine failure at the Fermi 2 nuclear plant, and recently issued NRC Information Notice 94-01, "Turbine Blade Failures Caused by Torsional Excitation (i.e., vibration) From Electrical System Disturbance," offer insights into UCS's concerns with the potential dangers of PILGRIM's cracked main turbine.

Boston Edison dismisses the lessons to be learned from the turbine failure at the Fermi plant by stating that the Fermi turbine was made by a different manufacturer than the PILGRIM turbine. However, UCS cited the Fermi turbine failure as evidence that a failure of <u>any turbine</u> can cause large vibrations. In the case of PILGRIM, the vibrations could increase the force on the existing cracks, but the NRC analysis of PILGRIM did not consider this.

Similarly, UCS cited NRC Information Notice 94-01,which describes how routine electrical disturbances can cause turbine vibrations that would significantly increase the force on the cracks in PILGRIM's turbine.

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Boston Edison has denied that PILGRIM is subject to the electrical disturbances the NRC warned against. However, our research of NRC reports contradicts Edison's claim. By 1987, the NRC had documented 20 events which caused loss of 345kV offsite power at PILGRIM. In the past 13 months, four of nine unplanned shutdowns involved "turbine load rejects", which are specifically cited in the NRC Notice, type 3, page 2 as having the potential to perturb the existing cracks.

Finally, Congressman Studds, something else is seriously wrong here. We have obtained a copy of a June 17, 1993 NRC internal memo, "PILGRIM UNIT 1: ASSESSMENT OF LOW PRESSURE TURBINE ANALYSIS," prepared for Project Director, Walter Butler by Engineering Chief, Jack Strosnider, which was the basis for Chairman Selin's August 4, 1993 response to you and CURE, "Enclosure 2" (appended). A comparison of the internal memo and the NRC response to you shows that the NRC is saying one thing on the "inside", and another on the "outside", about the danger of PILGRIM's cracked turbines.

The NRC's response to you is essentially a verbatim repetition of the internal memo, but there are glaring changes and omissions which, at best, could be viewed as an attempt by the NRC to downplay the safety hazards of PILGRIM's cracked turbine. At worst, they could represent a deliberate attempt to withhold vital safety information to deceive our Congressional leaders about potential dangers of PILGRIM's continued operation.

The critical importance of turbine deck orientation is outlined in NRC REGULATORY GUIDE 1.115, Protection Against Low-Trajectory Turbine Missiles, provided to you by the UCS. It warns, "..it is necessary to show that the risk from turbine missiles is acceptably small." It recites five principal means of safeguarding against such missiles and concludes, "...The first of these, *turbine orientation and placement*, provides a high degree of confidence that low-trajectory missiles resulting from turbine failures will not damage essential systems." (e.g., spent fuel storage pool, or impairment of vital control room functions) emphasis added.

Yet in response to you, the NRC removed key language from the assessment which reveals that PILGRIM's "...turbine deck is orientated unfavorably with respect to the reactor building." Also, in its response to you, the NRC says, "...(it) *desires* that the turbine *disk* failure probability be 1E-5 each year or lower for an unfavorably orientated turbine. (emphasis added) But on the "inside", the NRC says, "...(it) *requires* that the turbine *missile* failure probability be 1E-5 per year or lower for an unfavorably orientated turbine." (emphasis added)

On behalf of the 1,600 members of CURE, we ask you to lend the full support of your office to:

* seek an immediate commitment from the NRC to provide all information and analyses requested by UCS

* request the Government Accounting Office, the NRC Inspector General or other appropriate agency conduct an investigation to determine the reasons why the NRC's 6/17/93 internal memo differs from the NRC's 8/4/93 response to you

In recent weeks, the media has extensively exposed the past abuses of the atomic era. There is little comfort in this progress, when contemporary abuses are flagrant. We believe that the NRC has abdicated its role as a regulator, abused its authority and violated our trust. PILGRIM's continued operation has become an ongoing "cost versus safety battle," and we are bearing an unacceptable risk.

These are strong sentiments from a conservative safe energy group. But we have found our own truth, and we know that our situation is not unique. A congressional mandate for change is essential, lest the atomic abuses of today be revisited 50 years from now, and it will be too late.. Help us be a voice for change.

We greatly appreciate your involvement in our behalf on PILGRIM safety issues and look forward to hearing from you at your earliest convenience.

Sincerely yours,

Donald M. Muirhead Jr. M.D. Mary C. Ott

Dr. Donald M. Muirhead Jr. Mary C. Ott
Co-Chairmen

UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

COPY

JUN 17 1993

MEMORANDUM FOR: Walter R. Butler, Project Director
Project Directorate I-3
Division of Reactor Projects I/II

FROM: Jack R. Strosnider, Chief
Materials and Chemical Engineering Branch
Division of Engineering

SUBJECT: PILGRIM UNIT 1: ASSESSMENT OF LOW PRESSURE TURBINE ANALYSIS

During the refueling outage in April 1993, General Electric (GE) inspected the rotor in the low pressure turbine (LPA) at Pilgrim Unit 1 and found flaw indications in disk numbers 4, 5, 6, and 7. GE recommended that the licensee either remove the 7th stage disk on the generator side (7GA) or pre-warm the LPA rotor before startup. Subsequently, the licensee retained Structural Integrity Associates, Inc. (SIA) to evaluate flaw indications in the 7GA disk.

On May 12, 1993, the licensee provided to the NRC project manager the SIA analysis (Reference 1). The project manager requested that the Materials and Chemical Engineering Branch (EMCB) perform a review of the SIA analysis to determine 1) whether there is any gross error in the SIA analysis and 2) the potential impact to plant safety.

Pilgrim Unit 1 has two low pressure turbines, LPA and LPB, with shrunk-on disks. The turbine deck is orientated unfavorably with respect to the reactor building. The flaw indications of the 7GA disk are located in both the hub and web. Although the 4th and 5th stage disks have more and larger flaws than that in the 7GA disk, GE determined that the 7GA disk is the limiting disk based on operating conditions, fracture toughness of the disk, and potential consequences of the disk failure.

SIA performed parametric studies to determine effects of fracture appearance transition temperature (FATT), fracture toughness variability, pre-warming, crack growth rate and stress intensity models. The EMCB staff compared key parameters used in both the GE and SIA analyses to our estimates (see Attachment 1). Parameters used in the GE analysis were extracted from the SIA analysis because GE's analysis was not available at the time of this assessment.

Contact: John Tsao, DE/EMCB,
504-2702

9306240210 XA

June 17 - NRC memo

For the 7GA disk, GE reported one indication of 0.14 inch in the hub and an indication in the web which GE could not accurately size. For that indication, GE assumed a crack size of 0.25 inch based on flaw indications from other power plants' inspection data and laboratory data. The staff believes that the initial crack size of 0.25 inch is conservative but the staff could not quantify the uncertainty associated with the assumed size at this time.

GE used a fracture mechanics model of an edge crack in an infinite plate having constant loading. GE's model is conservative because it is more compliant than the actual geometry which is a radial crack emanating from the keyway. Moreover, its constant loading does not consider the radial decrease in hoop stress with increasing distance from the bore. SIA's model is a hole in an infinite plate with attenuated loading along the crack. The staff assumed a model of a thick wall cylinder with attenuated loading.

GE used 0.06 inch per year for the crack growth rate which was the median value taken from a statistical study of the average crack growth rate vs. wheel operating temperature from turbine inspection data of both BWR and PWR plants. SIA used 0.0164, 0.02, and 0.06 inch per year in its studies. The staff calculated a crack growth rate of 0.02 inch per year from previous inspection data of the LPA rotor. The staff believes that the actual crack growth rate may lie between 0.02 and 0.06 inch per year. However, according to GE's data, the upper bound growth rate (2 standard deviations) at an operating temperature of 172°F could be as high as 0.08 inch per year.

The critical stress intensity (K_{IC}) is an indicator of fracture toughness of the disk material. The lower the K_{IC} used in the fracture mechanics analysis the more conservative the results will be. GE's analysis used a lower bound value of 105 ksi√in which was taken from the graph of critical stress intensity vs. excess temperature (Test Temperature - FATT). The staff judges that the value of 105 ksi√in is conservative.

GE and SIA calculated a critical crack size (depth) of 0.34 inch and 0.54 inch, respectively. SIA conservatively assumed that the crack length is the length of the keyway bore. SIA indicated that if the crack aspect ratio is known, the critical crack size may be larger than 0.54 inch. Based on SIA's calculation, the critical crack size for the thick wall cylinder model is about 0.45 inch.

Based on the above parameters, the staff estimated a factor of safety on flaw size ranging from 1.21 to 3.6 based on the ratio between the crack length at end of the current fuel cycle in April 1995 to that of the critical crack size of the cylinder model. The factor of safety on stress intensity (K_I) ranges from 1.1 to 1.89 which was estimated by taking square root of the safety factor on flaw size.

The NRC requires that the turbine missile failure probability be 1E-5 per year or lower for an unfavorably oriantated turbine. GE's analysis is based on a turbine missile generation probability of 1E-5 failure per year. SIA did not perform a probabilistic fracture mechanics analysis. Based on engineering judgement, the staff estimated that the missile failure probability for the LPA turbine is between 1E-5 and 1E-4 per year. For this condition, the NRC permits the turbine to be kept in service until the next scheduled outage, at which time the licensee should take action to reduce the failure probability to the 1E-5 per year criterion (Ref. 2). The licensee has indicated that they are considering the replacement of both LPA and LPB rotors during the next scheduled refueling outage, which is expected to be April 1995.

Based on an assessment of the information available, the staff concludes that there is no safety concern for normal operation of the LPA turbine to the end of the current fuel cycle. The SIA analysis appears to reduce some of the obvious conservatisms used in the GE analysis.

Jack R. Strosnider, Chief
Materials and Chemical Engineering Branch
Division of Engineering

Enclosure:
Attachment 1: Pilgrim Turbine Evaluation
Attachment 2: References

cc: B. D. Liaw
R. Eaton
S. Shung

Enclosure 2

PILGRIM UNIT 1: ASSESSMENT OF LOW PRESSURE TURBINE ANALYSIS

During the refueling outage in April 1993, General Electric (GE) inspected the rotor in low pressure turbine "A" (LPA) at Pilgrim Unit 1 and found flaw indications in disks 4, 5, 6, and 7. GE recommended that the licensee either remove the seventh stage disk on the generator side (disk 7GA) or warm the LPA rotor before starting the turbine. The licensee later retained Structural Integrity Associates, Inc. (SIA) to evaluate flaw indications in disk 7GA.

On May 12, 1993, the licensee submitted the SIA analysis (Reference 1) to the NRC project manager, who requested that the NRC Materials and Chemical Engineering Branch (EMCB) review the SIA analysis to determine: whether there were any gross error in the SIA analysis and whether the flaws indications in the turbine disks would have any effect on plant safety.

Pilgrim Unit 1 has two low pressure turbines, LPA and LPB, with shrunk-on disks. The flaw indications of the 7GA disk are located in both the hub and web. Although the fourth and fifth stage disks have more and larger flaws than the 7GA disk has, GE determined that the 7GA disk is the limiting disk based on operating conditions, the fracture toughness of the disk, and the consequences of a disk failure.

SIA performed parametric studies to determine effects of the fracture appearance transition temperature (FATT), fracture toughness variability, pre-warming, crack growth rate, and stress intensity factors. The EMCB staff compared key parameters used in both the GE and SIA analyses to our estimates (see Attachment 1). Parameters used in the GE analysis were extracted from the SIA analysis because GE's analysis was not available at the time of this assessment.

For the 7GA disk, GE reported one indication of 3.556 mm [0.14 in] in the hub and an indication in the web which GE could not accurately size. For that indication, GE assumed a crack size of 6.35 mm [0.25 in] based on flaw indications from other power plants' inspection data and laboratory data. The staff believes that the initial crack size of 6.35 mm [0.25 in] is conservative but could not quantify the uncertainty associated with the assumed size.

GE used a fracture mechanics model of an edge crack in an infinite plate having constant loading. GE's model is conservative because it is more compliant than the actual geometry, which is a radial crack emanating from the keyway.

Moreover, its constant loading does not consider the radial decrease in hoop stress with increasing distance from the bore. SIA's model is a hole in an infinite plate with attenuated loading along the crack. The staff assumed a model of a thick wall cylinder with attenuated loading.

GE used a crack growth rate of 1.52 mm [0.06] inch each year, which was the median value from a statistical study correlating the average crack growth rate with the wheel operating temperature from turbine inspection data of both BWR and PWR plants. SIA used 0.416 mm [0.0164 in], 0.51 mm [0.02 in], and 1.52 mm [0.06 in] each year in its studies. The staff calculated a crack growth rate of 0.51 mm [0.02 inch] each year from previous inspection data of the LPA rotor. The staff believes that the actual crack growth rate may be between 0.51mm [0.02 in] and 1.52 mm [0.06 in] each year. However, GE's data indicate the upper bound growth rate (2 standard deviations) at an operating temperature of 78 °C [172 °F] could be as high as 2.03 mm [0.08 in] each year.

The critical stress intensity (K_{IC}) is an indicator of fracture toughness of the disk material. The lower the K_{IC} used in the fracture mechanics analysis the more conservative the results will be. GE used a lower bound value of 115 MPa√m [105 ksi√in] which was taken from the graph of critical stress intensity vs. excess temperature (test temperature - FATT). The staff finds that the value of 115 MPa√m [105 ksi√in] is conservative.

GE and SIA calculated the critical crack sizes (depths) of 8.64 mm [0.34 in] and 13.72 mm [0.54 in], respectively. SIA conservatively assumed that the crack length is the length of the keyway bore. SIA indicated that if the crack aspect ratio is known, the critical crack size may be larger than 13.72 mm [0.54 in]. SIA's calculation results in a critical crack size of about 11.43 mm [0.45 in] for the thick wall cylinder model.

Using the above parameters, the staff estimated a factor of safety for flaw size ranging from 1.21 to 3.6 based on the ratio between the crack length at end of the current fuel cycle in April 1995 to that of the critical crack size of the cylinder model (see attachment). The factor of safety for stress intensity (K_I) ranges from 1.1 to 1.89, which was estimated by taking square root of the safety factor for flaw size.

The NRC desires that the turbine disk failure probability be 1E-5 each year or lower for an unfavorably orientated turbine. GE's analysis is based on a turbine disk failure probability of 1E-5 failure per year. SIA did not perform a probabilistic fracture mechanics analysis. Using engineering judgment, the staff estimated that the turbine disk failure probability for the LPA turbine is between 1E-5 and 1E-4 per year. The NRC would permit a turbine in this condition to remain in service until the next scheduled outage, at which time the licensee should ensure they meet the turbine disk failure probability to the 1E-5 per year criterion (Attachment 2, Ref. 2).

Upon assessing the information available, the staff found no safety concern for normal operation of the LPA turbine to the end of the current fuel cycle, although the SIA analysis is less conservative than the GE analysis. The staff intends to perform a confirmatory review of the GE analysis and its methodology.

The Boston Edison Company has informed the NRC that it will be replacing both low pressure turbines during the next refueling outage, which is expected to be in April 1995.