BEFORE THE PUBLIC UTILITY COMMISSION

OF OREGON

UE 196

In the Matter of	)
	)
PORTLAND GENERAL ELECTRIC COMPANY	)
	)
Application to Amortize the Boardman Deferral.	)

DIRECT TESTIMONY OF

JOHN R. MARTIN, P.E.

ON BEHALF OF

THE INDUSTRIAL CUSTOMERS OF NORTHWEST UTILITIES

REDACTED VERSION

(Confidential Information Removed)

FEBRUARY 20, 2008

Q. PLEASE STATE YOUR NAME AND OCCUPATION.

A. My name is John Martin and I am the Principal of Pacific Energy Systems.

Q. PLEASE DESCRIBE PACIFIC ENERGY SYSTEMS' BUSINESS AND BUSINESS FOCUS.

A. Pacific Energy Systems is an energy-consulting firm that provides services to industries, utilities, institutions, and government agencies. Our staff has experience dealing with a wide range of power generating resources, including gas turbines, combined-cycle, cogeneration, steam, coal, biomass, waste-to-energy, and geothermal. The firm has prepared feasibility studies, plant optimizations, preliminary designs, project development plans, EPC specifications, and equipment procurement specifications. We also provide specialty services in the areas of development planning, regulatory review, operation and maintenance audits, and performance testing.

I. QUALIFICATIONS

Q. PLEASE DESCRIBE YOUR PROFESSIONAL QUALIFICATIONS, EXPERIENCE, AND EDUCATION.

A. I have over 41 years of engineering and project management experience in the development of thermal power systems, including design, construction, startup, and testing. Early in my career, Pratt & Whitney and Lockheed employed me in the design of aircraft propulsion systems. Bechtel subsequently employed me in the design of nuclear and fossil fueled power plants. At Pacific Power & Light, I was the Project Engineer for the design and construction of the Jim Bridger Power Plant, a 2000 MW coal-fired plant, in Rock Springs, Wyoming. I was subsequently employed by CH2M Hill, where I managed the Energy Systems

Department. In 1989, I started Pacific Energy Systems. At Pacific Energy Systems, I have been the Project Manager or the Principal-in-Charge of over 80 thermal energy and power generating projects performed by Pacific Energy Systems. I have provided expert witness testimony on behalf of clients seven times between 1981 and 2006. I hold B.S. and M.S. degrees in Mechanical Engineering from the University of California at Berkeley and UCLA, respectively. I am a registered professional engineer in Oregon, Washington, and California. A more complete resume is provided in Exhibit ICNU/101.

Q. HAVE YOU APPEARED AS AN EXPERT IN OTHER PROCEEDINGS INVOLVING ROOT CAUSE ANALYSES?

A. Yes. I served as an expert witness on behalf of a client that was involved in litigation concerning damage to a steam turbine at a 500 MW power plant in Nevada. In that case, I was asked to evaluate several root cause analyses, and to provide an opinion on the completeness and accuracy of the conclusions in the root cause analyses.

II. INTRODUCTION & SUMMARY

Q. WHO ARE YOU REPRESENTING IN THIS PROCEEDING?

A. I have been retained by the Industrial Customers of Northwest Utilities ("ICNU") to review the prudence of Portland General Electric Company's ("PGE") actions related to the procurement, installation, operation, and maintenance of a new steam turbine generator at the Boardman Power Plant. Specifically, I have been asked to address the causes and circumstances surrounding the failure of the low-pressure steam turbine No. 1 ("LP1") rotor in 2005.

Q. PLEASE DESCRIBE HOW YOU PERFORMED YOUR REVIEW.

A. I reviewed PGE's testimony and exhibits and the numerous documents that PGE provided during discovery in this proceeding. The documents I reviewed are included in the list of documents in Exhibit ICNU/102.

Q. PLEASE SUMMARIZE YOUR CONCLUSIONS.

A. My conclusions are divided into the following four subject areas:

- PGE's responsibilities for the failure of the LP1 turbine rotor and the 2005 outage;
- Siemens Westinghouse's ("Siemens") responsibilities for the LP1 turbine rotor failure;
- The results of the root cause analyses; and
- Technical reasons for the failure.

CONCLUSIONS – PGE'S RESPONSIBILITIES

In my opinion, PGE bears responsibility for the turbine failure, and the subsequent outage, for the following reasons:

1. In the February 18, 1999 Turbine Upgrade Contract between Siemens and PGE to replace the low pressure turbine ("Turbine Upgrade Contract"), [redacted]
2. [redacted]
3. [redacted]

[redacted]

4. PGE did not cover the risk associated with the installation and validation of a new turbine design. [redacted] In addition, PGE did not arrange for any risk mitigation, such as business interruption insurance, boiler and machinery insurance, or optional standby power contracts. These types of insurance and risk mitigation are available in the marketplace.

5. When the new turbines were installed in 2000 and 2004, PGE did not provide for independent quality assurance and quality control to monitor Siemens' installation of the new equipment. In addition, PGE did not provide for independent quality assurance and quality control to monitor Siemens' maintenance of the turbines. PGE simply stated that it depended on Siemens, [redacted] it was not prudent for PGE to rely on Siemens for quality assurance and quality control.

6. [redacted]

CONCLUSIONS – SIEMENS' RESPONSIBILITIES

In my opinion, Siemens bears responsibility for the turbine failure for the following reasons:

1. PGE depended on Siemens [redacted] to design, manufacture, install, and maintain the turbine. The turbine should have safely operated for at least 40 years; however, the turbine rotor failed in five and one-half years. The turbine rotor should not have failed within such a short time period. The failure of a new, large steam turbine rotor after only five and one-half years of operation is simply unheard of, and clearly does not meet the standards of the electric power industry.
2. Siemens failed to meet its obligations to PGE to adequately design, manufacture, install, and maintain the turbine.
3. Siemens failed to meet its warranty obligations. [redacted]
4. The Siemens' root cause analysis is incomplete and based on invalid assumptions and conclusions.

5. Because of its stated contract objective [redacted] Siemens should have performed a complete and objective analysis of the failure.
6. The alignment of the turbine by Siemens during the installation and the subsequent maintenance of the turbine appear to be major contributing factors to the failure of LP1. The design of the turbine may also be a contributing factor.

CONCLUSIONS – ROOT CAUSE ANALYSES

I have reached the following conclusions regarding the root cause analyses that were conducted:

1. None of the root cause analyses considered the full range of factors that led to the failure. These factors include business issues, management actions or inactions, technical design, maintenance, quality control, and other contributing factors.
2. Only two root cause analyses of the failure were prepared: one by Alstom, and one by Siemens. Neither Alstom nor Siemens is a truly independent and unbiased party.
3. PGE did not conduct a root cause analysis, nor did its consultant M&M Engineering.
4. The root cause analyses by Alstom and Siemens conclude that the failure occurred because of high-cycle fatigue that was exacerbated by significant misalignment of the LP1 shaft.

5. The Alstom and Siemens root cause analyses are incomplete because they did not fully investigate the source and cause of the misalignment, the adequacy of the design, and other related issues that led to the failure.

CONCLUSIONS – TECHNICAL REASONS FOR THE FAILURE

I have reached the following conclusions concerning the technical reasons for the turbine failure:

1. The LP1 rotor failed because of metal fatigue caused by a combination of cyclic bending stresses and torsional stresses. The rotor failure is a classic example of a fatigue failure in a rotating shaft that is carrying both torsional and bending loads.
2. In the case of the LP1 rotor, the bending loads are primarily produced by the weight of the rotor, vertical operating loads, and shaft misalignment.
3. The bending stresses in the rotor appear to have been increased by the misalignment of the rotor.
4. [redacted] If the alignment changes were incorrect, and not compatible with the rotor design, this would have been a contributing factor.
5. [redacted]

III. ANALYSIS OF THE BOARDMAN OUTAGE

Fatigue Failure

Q. PLEASE DESCRIBE WHAT CAUSES A FATIGUE FAILURE.

A. Cycling or alternating stresses are the primary cause of fatigue failures. People are generally familiar with how a thin piece of metal will crack and fail if it is bent back and forth repeatedly. For a rotating shaft that is carrying bending loads such as the weight of the rotor, the bending stresses at a point on the shaft change from compression to tension with each revolution. The LP1 rotor rotates 60 times each second and, thus, the bending stresses also cycle 60 times each second. Fatigue failures normally begin with a small surface crack in the metal and commonly occur at a point of discontinuity [redacted] PGE/105C-B, Quennoz/31. In the case of the LP1 rotor, the location of the failure is exactly where one would expect it to occur because of the reduced diameter and the abrupt nature of the "J" groove. The reduced diameter increases the torsional and bending stresses, and the "J" groove acts as a point of stress concentration.

Q. PLEASE DESCRIBE HOW A FATIGUE FAILURE PROGRESSES.

A. Fatigue failures occur in two stages. The first stage normally develops slowly without any signs over a period of years, during which a crack will develop and grow in size. The second stage of a fatigue failure is characterized by a sudden, catastrophic failure. There is normally little or no warning before a fatigue failure occurs. The Boardman facility was fortunate not to experience a sudden, catastrophic failure, which could have caused extensive damage to the entire plant, and might have killed or gravely injured any staff members in the vicinity.

Q. ARE FATIGUE FAILURES COMMON IN STEAM TURBINES?

A. A fatigue failure in a large steam turbine rotor is very unusual. Attached as Exhibit ICNU/103 are referenced excerpts from the Turbine Upgrade Contract, [redacted] ICNU/103, Martin/8. The LP1 rotor failed approximately five and one-half years after initial startup. If metal fatigue was the primary determinant to the rotor life, one would expect the rotor to be designed for a minimum of [redacted] assuming a minimum safety factor of [redacted], that Siemens reportedly uses as its minimum design criteria. PGE/105C-A, Quennoz/3. The rotor failed after approximately 8.5 x 10^9 cycles, or about [redacted] percent of the expected stress cycles. Failing after only [redacted] percent of the design stress cycles would require an extreme level of misalignment and calls into question the fundamental design, construction, and installation of the rotor.

Q. WHAT ARE THE POSSIBLE CAUSES OF THE MISALIGNMENT IN LP1?

A. The shaft misalignment could have been caused by an incorrect setting of the bearing elevations. The bearing elevations were substantially changed several times between the time of installation in 2000 and the time of the failure in 2005. This raises the questions: 1) Why were the elevations changed; and 2) What are the correct elevation settings? [redacted]

[redacted] PGE/105C-B, Quennoz/35. As discussed in the Alstom root cause analysis, [redacted] Id. at 25.

[redacted]

Q. WHO WAS RESPONSIBLE FOR ALIGNING THE TURBINE SHAFT?

A. [redacted] ICNU/103, Martin/3-7. Siemens also provided contract maintenance and warranty work on the low-pressure turbine after the installation in 2000. Siemens replaced bearings Nos. 3, 4, 5, and 6 under warranty in the summer of 2002 with a tilt-pad design. PGE/100, Quennoz/9. Siemens reported no bearing alignment changes at that time. In 2004, under a contract with PGE, [redacted] when the new High Pressure/Intermediate Pressure ("HP/IP") turbine rotor was installed. PGE/105C-B, Quennoz/25.

Q. WHAT IS THE BASIS FOR YOUR OPINION CONCERNING THE TYPE OF FAILURE THAT OCCURRED?

A. I base my opinion on my education, training, experience, the root cause analyses prepared by Alstom and Siemens, and the documents produced by PGE.

Q. WHAT DID THE ROOT CAUSE ANALYSES BY ALSTOM AND SIEMENS CONCLUDE?

A. The root cause analyses by Alstom and Siemens conclude that the failure occurred because of high-cycle fatigue, which was attributed to significant misalignment of the LP1 shaft. Both analyses, however, are incomplete, because they did not fully investigate the source and cause of the misalignment, the adequacy of the design, and other related issues.

Q. WHAT WERE THE SPECIFIC CONCLUSIONS IN THE ALSTOM ROOT CAUSE ANALYSIS?

A. The Alstom analysis is the most complete and technically well supported. [redacted] PGE/105C-B, Quennoz/41. According to Alstom, the primary propagation factor of the cracked rotor was [redacted] Id. [redacted] Id. [redacted] Id. The misalignment could have been [redacted] Id. [redacted] Id.

While the Alstom conclusions are technically well supported, the analysis is incomplete and should be continued to address the following key questions:

1. Was the design of the LP1 turbine a contributing factor?
2. Was the turbine misaligned by Siemens?
3. Was the Siemens alignment profile incorrect?
4. Did PGE modify the unit alignment and contribute to the failure?
5. Did the upgrade to the HP/IP turbine in 2004 contribute to the failure?
6. Did the high operating capacity of the unit contribute to the failure?

Q. WHAT WERE THE SPECIFIC CONCLUSIONS IN THE SIEMENS ROOT CAUSE ANALYSIS?

A. [redacted] PGE/105C-C, Quennoz/35. Siemens' conclusion that the misalignment was caused by an "**unknown**" operational condition has no basis in fact. Other possible reasons for the misalignment are:

1. The original bearing alignment was incorrect;
2. The changes to the bearing alignment made by Siemens were incorrect;
3. The installation work performed by Siemens caused the misalignment; and
4. The designs of the new turbine components were not compatible with the original installation.

The Siemens analysis concluded that the turbine design and PGE's operation of the turbine were not causes. Id. My experience with root cause analyses in adversarial situations is that they are normally performed to avoid responsibility rather than truly find the causes of a failure. It would be unlikely that the Siemens root cause analysis would conclude that Siemens or PGE was responsible for the failure. In essence, Siemens had a conflict of interest in performing the root cause analysis. The same might be said about the Alstom analysis because Alstom had a prior contract relationship with PGE. While the Alstom analysis was superior to that performed by Siemens, it was not a complete analysis.

Q. WHAT WERE THE SPECIFIC CONCLUSIONS IN THE PGE ROTOR FAILURE INVESTIGATION?

A. PGE's report, entitled "PGE Boardman LP1 Rotor Failure Investigation," was not a root cause analysis. PGE/105C-A, Quennoz/1. The report provided a background on the failure, and an analysis and summary of the Alstom and Siemens root cause analysis reports. The PGE report's conclusions were similar to those of Alstom and Siemens, and emphasized that there was no evidence the turbine was mis-operated by PGE.

Q. WHAT IS THE IMPACT OF FAILING TO IDENTIFY THE ROOT CAUSE?

A. It is extremely important that the root cause analyses be completed to ensure that the failure does not reoccur. If the root cause is not identified, the LP1 rotor could fail again. A catastrophic failure of the LP1 rotor could destroy a significant portion of the Boardman Plant and kill or severely injure plant staff. The economic and human consequences of a catastrophic failure are orders of magnitude greater than the cost to finish the root cause analysis. Steps can and should be taken to prevent a recurrence. In addition, a failure would expose PGE and its ratepayers to unknown, future market purchases of power.

Q. DO YOU AGREE WITH STEPHEN QUENNOZ'S STATEMENT ON PAGE FOUR OF HIS TESTIMONY (PGE/100, QUENNOZ/4) THAT "WHAT CAUSED THE CRACK REMAINS UNKNOWN?"

A. No. The root cause analyses performed by Alstom and Siemens, and PGE's report, all agree that the failure of the LP1 rotor was caused by metal fatigue produced by the misalignment of the shaft. There is no mystery about the type of failure or some of the principal causes. Both root cause analyses, and PGE's report, fail to address why the rotor was misaligned, and who was responsible.

Q. ON PAGE SEVEN OF HIS TESTIMONY, MR. QUENNOZ IMPLIES THAT NEITHER SIEMENS NOR ALSTOM WERE ABLE TO PINPOINT THE ROOT CAUSE OF THE FAILURE. PGE/100, QUENNOZ/7. DO YOU AGREE?

A. No. Mr. Quennoz's statement that none of the analyses could determine a **single** root cause gives the impression that Siemens and Alstom did not know the primary reason for the failure, and that the cause is mysterious. Mr. Quennoz's statement is correct in the sense that a single cause was not identified. The name "root cause analysis" gives the impression that failures have only one cause, but this is never true. A root cause analysis always identifies a number of causes. All failures occur for numerous reasons. The technical cause of the LP1 rotor failure is metal fatigue resulting from a combination of torsional and cyclic bending stresses that were magnified by the misalignment of the rotor. However, as I have discussed elsewhere in my testimony, there are other causes of the failure that relate to business decisions, management, quality control, manufacturing, etc., that could be contributing factors. There is no reason why these factors should not have been evaluated in the root cause analyses.

Q. DID PGE OPERATE THE STEAM TURBINE AT OUTPUT LEVELS IN EXCESS OF ITS DESIGN RATING?

A. Yes, Exhibit ICNU/104 shows the plant operating data from July 2000 through December 2007. The design output capacity of the steam turbine generator after the 2000 modifications to the low-pressure turbines was 580 MW. However, from 2000, through the time of failure in 2005, [redacted] The HP/IP modifications that occurred in 2004 increased the capacity to 617 MW. After the failure in 2005, the Boardman Plant, with minor exceptions, [redacted]

Q. WHAT ARE THE EFFECTS OF OPERATING THE STEAM TURBINE IN EXCESS OF ITS DESIGN RATING?

A. The operating torsional stresses in the rotor are directly proportional to the turbine power. The higher power operation of the turbine between July 2000 and December 2004 would increase the maximum operating torsional stresses by about seven percent. Thus, while the higher output operation likely contributed to the failure of the LP1 rotor, it does not appear to be a major contributor to the failure.

Q. WAS PGE NEGLIGENT IN OPERATING THE TURBINE ABOVE ITS DESIGN CAPACITY?

A. No, it does not appear so. If the turbine was properly designed, manufactured, installed, and maintained, the operation of the turbine above its design capacity should not have caused the failure. It is my opinion that the turbine had inherent defects, and those defects would have caused the failure in any case. The inherent defects were related to the rotor misalignment, strength of its supporting structure, and, possibly, the design. Nevertheless, the higher load operation would have caused the failure to appear sooner.

Q. DID SIEMENS' 2004 MODIFICATIONS TO THE HP/IP TURBINE CONTRIBUTE TO THE FAILURE OF LP1 IN 2005?

A. Yes. The higher output of the HP/IP turbine increased the torsional shear stresses carried by the LP1 rotor. When combined with the cyclical bending stresses, the additional torsional shear stresses created by the 2004 modifications to the HP/IP turbine would have been a contributing factor to the failure of the LP1 rotor in 2005. The 2004 HP/IP modifications increased the power output from both the HP/IP turbine and the two low-pressure turbines (LP1 and LP2). The increased output from the HP/IP turbine was a result of higher turbine efficiency and an increase in the steam flow through the HP/IP turbine. The increased output of the HP/IP turbine caused an increase in the power and torque—by about eight percent—that was carried through bearing No. 3 into the LP1 rotor, which, in turn, would have increased the torsional stresses by eight percent at the point of failure when the unit was operating at its design rating.

In the absence of cyclical bending loads, this increase in non-cyclical torsional shear stresses would not cause a fatigue failure and would be well within the range of the load carrying capacity of the rotor. However, when combined with the cyclical bending loads, the additional torsional stresses would have contributed to the failure of the LP1 rotor in 2005.

Another very important question that should be investigated is whether the loose and missing fasteners that were discovered by PGE in 2006 were caused by Siemens during the low-pressure turbine replacement in 2000 and the HP/IP turbine modifications in 2004. It should be determined whether Siemens' staff removed these fasteners in the course of their installation work.

The Turbine Upgrade Contract

Q. WHO SHOULD BEAR RESPONSIBILITY FOR THE LP1 FAILURE?

A. Both Siemens and PGE should bear responsibility for the failure. I will first explain why Siemens is responsible.

Based on my review of the Turbine Upgrade Contract documents, it is my opinion that Siemens failed to meet its warranty obligations to design, fabricate, supply, install, and maintain the low-pressure turbine. The turbine, which had a 10-year warranty under the Turbine Upgrade Contract, failed after approximately five and one-half years of operation. ICNU/108, Martin/1. A large steam turbine rotor should never fail after only five and one-half years of operation and six percent of the design cyclic stresses. I have never heard of a failure of a relatively new, large steam turbine rotor. Moreover, the low-pressure turbine had a specified design life of [redacted] years. ICNU/103, Martin/8. Normal electric utility design standards for large rotating equipment are very conservative due to the significant dangers of a catastrophic failure. One would expect the turbine to safely operate for at least 40 years.

The loose and missing fasteners that PGE discovered in 2006, which probably contributed to the failure, also may have been Siemens' responsibility. Siemens was involved with the modification of the HP/IP and low-pressure turbines between 2000 and 2005. Siemens may have left the fasteners unsecured when the HP/IP turbine was being replaced.

Q. WAS THE LP1 TURBINE AN UNTESTED DESIGN?

A. [redacted] ICNU/103, Martin/3. [redacted] Id. [redacted] Id. [redacted] This is a very unusual undertaking for a public utility since most utilities do not want to be test-beds for new equipment, due to the inherent risks involved, such as catastrophic failures, costs of repairs, and costs of replacement power at market prices.

Q. DO YOU BELIEVE PGE ALSO SHOULD BEAR RESPONSIBILITY FOR THE FAILURE?

A. Yes. PGE is responsible for the management and integrity of its facilities. The installation of the new turbine rotors was a major modification to the Boardman Plant. PGE decided to participate in the development of a new turbine design at Boardman, but did not protect itself in the Turbine Upgrade Contract, did not purchase insurance, and did not purchase optional standby power. In addition, PGE did not pursue Siemens under the warranty provisions of the Turbine Upgrade Contract.

When PGE was asked in these proceedings about its quality control ("Q/C") and quality assurance ("Q/A") programs, it responded that it depended on Siemens' Q/C and Q/A programs. ICNU/105, Martin/1. That is not a responsible management position. Independent, quality reviews of a major modification are essential. Furthermore, by relying on Siemens, PGE was relying on an entity that, under the terms of the Turbine Upgrade Contract, [redacted]

If the LP1 rotor experienced a catastrophic failure and damaged the entire plant, [redacted] Essentially, PGE is responsible for the prudent design, operation, and maintenance of its system. PGE cannot avoid its responsibilities simply by attempting to contract them away.

[redacted]. ICNU/103, Martin/3, 16-17. [redacted] Id. at 16-17. The validation of the low-pressure design would require more than one year.

Q. WAS PGE GIVEN ANY FINANCIAL INCENTIVE TO INSTALL THE NEW LOW PRESSURE TURBINE?

A. Yes, under the Turbine Upgrade Contract, [redacted] ICNU/103, Martin/9. It appears that PGE received a $1.4 million credit from Siemens when it installed the new HP/IP turbine in 2004. ICNU/106, Martin/1.

Q. DID PGE PROTECT ITS OWN INTERESTS IN THE TERMS OF THE TURBINE UPGRADE CONTRACT?

A. No, PGE should have protected itself from the cost of replacement power, either in the terms of the Turbine Upgrade Contract, or through procuring insurance. The Turbine Upgrade Contract indicated that PGE would be protected from the risk of [redacted] ICNU/103, Martin/3. PGE, however, did not protect itself from the cost of replacement power—the largest monetary risk involved. The Turbine Upgrade Contract specifically provided that [redacted] ICNU/103, Martin/10-11.

PGE has explained that, to its knowledge, "there are no equipment manufacturers that will enter into a contract that contains penalties for consequential damages." ICNU/107, Martin/1. PGE further explained that it "does not have, nor has it ever had, business interruption or consequential damage insurance for any of the thermal plants such as Boardman." Id. Even if equipment manufacturers such as Siemens typically will not agree to be responsible for consequential damages, PGE still could have procured business interruption, boiler, and machinery insurance policies and contracted for standby power. These types of risk mitigation are available in the marketplace.

Q. DID PGE PROTECT ITS OWN INTERESTS UNDER THE TURBINE UPGRADE CONTRACT'S WARRANTY PROVISIONS?

A. PGE has stated that it filed a warranty claim in 2005 for a new LP1 rotor after the failure occurred. ICNU/108, Martin/1. PGE stated that it based its claim on the warranty provision of the Turbine Upgrade Contract. Id. PGE further stated that Siemens denied PGE's claim "because in Siemens' view, the root cause analyses did not support a conclusion that the turbine had defects or faults." Id. This statement does not follow, since the root cause analyses were completed in 2007, long after PGE made its 2005 warranty claim. The Siemens root cause analysis is dated March 8, 2007, or approximately 16 months after the failure and the filing of the warranty claim. PGE 105C-C, Quennoz/1.

The LP1 rotor crack was discovered on November 18, 2005, and the shaft was shipped to Alstom within two weeks for repairs. PGE/100, Quennoz/3. PGE stated that during the two-week period it obtained competitive repair proposals from Siemens and Alstom, and that Alstom was selected based on the fact that Alstom could complete the work faster. PGE/100, Quennoz/4. PGE, however, had the right under the Turbine Upgrade Contract warranty [redacted] ICNU/103, Martin/13-15.

ICNU has requested additional details to substantiate PGE's assertion that it made a warranty claim to Siemens, which was denied. The responses to these data requests are not yet due. However, PGE has provided a letter from Siemens, dated December 13, 2005, which states, [redacted] ICNU/109, Martin/1. [redacted]

Q. BASED ON THE INFORMATION YOU HAVE REVIEWED, WHAT DO YOU BELIEVE WAS THE ROOT CAUSE OF THIS FAILURE?

A. I have a preliminary opinion concerning the root **causes** for the failure. All of the parties associated with this case should complete the root cause analyses and learn from them so that the failure does not reoccur. The catastrophic failure of the turbine operating at full load could destroy much of the plant, kill staff members, and cause economic losses far in excess of any costs experienced as a result of the 2005 failure.

As previously mentioned, a root cause analysis rarely, if ever, reaches a conclusion that a failure has a **single** cause. Failures occur because of a chain of events, or causes that can be categorized into areas such as business decisions, management actions or inactions, technical design, maintenance, quality control, among others. My preliminary opinion is that the following are some, but not all of the causes of the Boardman turbine failure and the associated costs for replacement power and the repair of the facility:

1. PGE decided to participate in the development of a new turbine design;
2. PGE did not cover the risks through its contract with Siemens, or by purchasing insurance or optional standby power contracts;
3. PGE did not pursue Siemens under the warranty provisions of the Turbine Upgrade Contract;
4. There was a lack of independent quality assurance and quality control;
5. Siemens failed to meet its obligations to PGE to design, manufacture, install, and maintain the turbine according to industry standards;
6. Technically, the LP1 rotor failed because of metal fatigue caused by a combination of cyclic bending stresses and torsional stresses;
7. The bending stresses in the LP1 rotor appear to have been increased by the misalignment of the rotor;
8. Siemens substantially changed the LP1 rotor alignment on several occasions after the initial installation in 2000 until the time of the failure in 2005. If the

alignment changes were incorrect, and not compatible with the rotor design, this would have been a major contributing factor; and

9. An additional contributing factor was the missing and loose fasteners on the supporting structure for bearings No. 2 and No. 3, which were discovered in 2006.

In addition to the factors noted above, there are several remaining questions that should be evaluated, including the following:

1. Was the design of the low-pressure turbine a contributing factor?
2. Were the HP/IP turbine modifications a contributing factor?
3. Was the turbine misaligned by Siemens?
4. Was the Siemens alignment profile incorrect?
5. Did PGE modify the unit alignment and contribute to the failure?

The opinions noted above are based on the information I reviewed. It is highly recommended that the root cause analyses be completed and that a qualified, independent third party perform any further analysis.

Q. BASED ON YOUR ANALYSIS, WHAT ACTION SHOULD THE COMMISSION TAKE IN THIS CASE?

A. I understand the objective of these proceedings is to determine whether PGE can recover the extra cost for replacement power during the time the Boardman turbine was being repaired. As I have discussed, both PGE and Siemens bear responsibility for the failure. Siemens was relieved of its responsibility in the Turbine Upgrade Contract with PGE. I do not believe that ratepayers are responsible for the decision to install a new turbine or to manage the design, installation, and maintenance, nor do I believe that the ratepayers are in a position to manage the associated risks. I believe the fundamental mistake that occurred was the decision by PGE management to join Siemens in developing a new turbine design and not covering the associated risks. Siemens' risks were small compared to PGE's, and Siemens was able to develop new technology while PGE took the risk. I do not believe that the ratepayers should be responsible for the cost for replacement power.

Q. DOES THIS CONCLUDE YOUR TESTIMONY?

A. Yes.

BEFORE THE PUBLIC UTILITY COMMISSION

OF OREGON

UE 196

	)
In the Matter of	)
	)
PORTLAND GENERAL ELECTRIC COMPANY	)
	)
Application to Amortize the Boardman Deferral.	)
	)

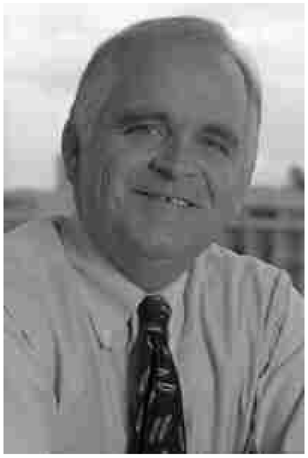
ICNU/101

JOHN R. MARTIN QUALIFICATIONS

FEBRUARY 20, 2008

ICNU/101

John R. Martin, P.E., Principal



EDUCATION

- M.S., Mechanical Engineering, University of California, Los Angeles
- B.S., Mechanical Engineering, University of California, Berkeley
- Additional graduate studies in management and economics

PROFESSIONAL REGISTRATION

Professional Engineer: California, Oregon, Washington

EXPERIENCE

Mr. Martin is the Principal of Pacific Energy Systems, Portland, Oregon. He is responsible for the general management and technical quality of all major projects performed by Pacific Energy Systems and also provides consulting services directly to clients.

Mr. Martin has been the Project Manager or the Principal-in-Charge of over 80 thermal energy power and cogeneration projects performed by Pacific Energy Systems in the last 19 years. These projects include responsibility as the Owner's Engineer/Project Manager and the Bank's Engineer and cover all phases of project development including feasibility assessment, site selection, financing, permitting, preliminary design, and project management during detailed design, construction, start-up and testing.

Mr. Martin was the Owner's Project Manager for the development of a 43-MW peak power generating facility for the Franklin County Washington PUD and the Grays Harbor PUD. This included the specification and purchase of the gas turbine generators, CO and NO_X catalyst and the preparation of preliminary design. The preliminary design included heat and mass balances, air emissions, water balances, flow diagrams, and initial plant layouts to support project permits. Mr. Martin prepared specifications to select a design and construction management firm to build the facility. He represented the Owners through design, construction and start-up. Because of the critical need for electricity, the schedule for this $34 million project from start of detailed design to initial operation was compressed to seven months.

Mr. Martin was the Owner's Engineer for the design and construction of a 27-MW simple-cycle combustion turbine power plant for the Benton County Washington PUD. He was responsible for helping the PUD purchase the gas turbine generator and the preliminary design necessary to obtain land-use and air permits. The preliminary design included preparation of heat and mass balances, air emissions, water balances, flow diagrams, design criteria, and initial plant layouts. Mr. Martin prepared the Engineering, Procurement, and Construction (EPC) specifications that were used to select a turnkey EPC contractor. Pacific Energy Systems is providing engineering services to the Owner during the design and construction of the facility. Because of the critical need for electricity, the project schedule from the start of detailed design to initial operation is approximately six months.

Mr. Martin was the Owner's Engineer for United Technologies Energy Holdings (UTEH) for the design and construction of seven, 50-MW simple-cycle peak power generating plants in California. In this capacity, Mr. Martin prepared specification to retain a design, procurement, and construction management firm to develop the projects.

Mr. Martin was the Owner's Engineer for Avista-Steag for the development of a 250-MW gas turbine combined cycle at the Mint Farm Industrial Park in Longview, Washington. He was responsible for the preliminary design that included preparation of heat and mass balances, plant emissions, water balances, flow diagrams, and initial site arrangement drawings. The preliminary design documents were used for project permitting.

Mr. Martin was responsible for the preparation of the preliminary design for the Sempra Energy Resources' El Dorado Generating Station Phase II expansion southwest of Boulder City, Nevada. The facility is a 550-MW gas turbine combined-cycle power plant. The preliminary design included development of the plant design criteria, heat and mass balances, air emissions, water balances, flow diagrams, one-line diagrams, plant arrangements and elevation drawings, and plant descriptions, The preliminary design was prepared for both General Electric 7FA and Westinghouse/Siemens 501 gas turbine generators and was used to obtain the permits to construct the facility. The permits were successfully obtained. Mr. Martin was also retained by Sempra Energy Resources to prepare standard specifications for the engineering, procurement, and construction of a standard 550-MW combined-cycle power plant.

Both Westinghouse Credit Corporation and ABN AMRO Bank have retained Mr. Martin as independent engineer. As the independent engineer for the Ryegate and Soledad Biomass Projects, he was responsible for preparing a technical evaluation report before project financing was completed and, subsequently, for monitoring monthly construction progress. Monthly construction progress reports were prepared together with monthly certificates of completion. Mr. Martin also conducted an operations and maintenance audit of the Soledad Biomass Power Plant, including an independent review of the cost of producing the biomass fuel.

Westinghouse Credit Corporation also retained Mr. Martin to perform a technical review of the Molokai Biomass Project in Hawaii. The review included observation and evaluation of plant performance tests and a technical review of the plant design and operation. The costs for producing the biomass fuels were also evaluated to better understand the cost of plant operation. Mr. Martin was the Owner's project manager for the development of a 65-MW cogeneration facility for the Blue Heron Paper Company in Oregon City, Oregon. This included preparation of a plant energy plan and a project feasibility study.

Mr. Martin was the project manager for the initial evaluation of gas turbine cogeneration facilities for the Public Utility District of Grant County (Washington) and the Springfield Utility Board (Oregon). Projects were designed to provide steam to local industries and electricity for the utilities and were based on the use of natural gas combustion turbines. He was also responsible for the evaluation of an electric power generating facility that would be located at a natural gas storage facility in Oregon. The evaluation included the conceptual design of the gas turbine generation facility and the development of capital, operation, and maintenance costs.

Mr. Martin has been retained by two confidential clients to select sites for new electric power generating facilities in California, Oregon, and Washington. The site selection process included screening potential sites for the required infrastructure, land use and environmental characteristics necessary for new plant development.

Mr. Martin was the project manager for the design and construction of two hydroelectric power plants (24-MW and 12-MW) that were built for the City of Portland. He also performed project due diligence reviews for the Auger Falls Hydroelectric Power Project in Idaho and the Waialua Hydroelectric Project in Hawaii.

He performed cogeneration feasibility studies at Crown Zellerbach's (now James River Corporation) Wauna, Oregon, paper mill for the Clatskanie Public Utility District, and was responsible for a fuel conversion and cogeneration study for the R.T. French Company, Shelley, Idaho. He performed heat recovery feasibility studies for the Georgia-Pacific Corporation's Lovell, Wyoming, gypsum plant and for the City of Lake Oswego, Oregon. The Lake Oswego project analyzed the possible use of recovered heat for district heating.

Earlier, Mr. Martin was responsible for the design of a gas turbine power plant that would use landfill gas recovered from Rossman's Landfill in Oregon City, Oregon. He also performed a feasibility study for the addition of heat recovery boilers and a steam turbine-generator at the City of Honolulu's Waipahu incinerator. In Florida, he was responsible for the preliminary design for the City of Tampa's McKay Bay Refuse-to-Energy Project, including heat recovery boilers, steam turbine-generators, and air pollution control systems.

He performed a Best Available Control Technology (BACT) evaluation that considered using emulsified No. 2 fuel oil and water in medium-speed diesel engines at the Maui

Electric Company's (MECO) Maalaea Power Plant. In addition, he was responsible for evaluating cogeneration opportunities for a food processing plant within MECO's service area.

Mr. Martin was project manager for the conceptual design of renewable energy systems to be demonstrated at the Natural Energy Laboratory of Hawaii. These renewable systems include solar thermal collection and storage, absorption refrigeration, and low-temperature desalination.

Mr. Martin was the independent engineer for Westinghouse Credit for the design and construction of a 42-MW combined cycle at Sanger, California. The work included construction and performance test monitoring.

He assisted a client with negotiations in China for the turnkey development of small (12-MW), coal-fired electric power plants. Negotiations involved representatives of the local electric utility, the Bank of China, county officials, and representatives of the Chinese trading company.

In the early 1970's, while employed by Pacific Power & Light Company, Mr. Martin was involved in project engineering and project management of new power generating facilities. He was project engineer for Pacific Power's Jim Bridger Project in Rock Springs, Wyoming, and was responsible for coordinating engineering, equipment procurement, and construction package preparation with the architect/engineer, the Pacific Power home office, and the field construction office. In addition, he was responsible for monitoring engineering budgets and schedules to meet project cost and schedule requirements. While at Pacific Power, Mr. Martin was also involved in the design of betterment projects for steam electric generating plants, including scrubber retrofit studies for the Jim Bridger plant. He assisted in the development of standard criteria for the design of coal-fired generating facilities, and he recommended an information management system for storage and retrieval of drawings and data on new plant design projects.

Mr. Martin also served as an engineer for the Bechtel Power Corporation. He was involved in mechanical group supervision of the Taiwan Power Company's Nuclear Units 3 and 4 and Units 5 and 6 projects, and was responsible for engineering planning and scheduling, budget preparation, specifications, bid evaluations, equipment sizing, and design calculations. He supervised preliminary design studies and technical administration of the turbine-generator contract for Gulf States Utilities' Blue Hills Project and preliminary plant design studies for the German utility RWE.

Earlier, Mr. Martin worked with Lockheed Aircraft and Pratt and Whitney Aircraft, where he was primarily involved in cycle design and optimization of gas turbine engines for commercial and military aircraft.

He has taught courses in engineering thermodynamics and thermal systems design at Portland State University.

PROFESSIONAL REGISTRATION

Professional Engineer: California, Oregon, Washington

MEMBERSHIP IN PROFESSIONAL ORGANIZATIONS

- Member, ACEC - Oregon
- Fellow, American Society of Mechanical Engineers (ASME)
- Vice President, ASME Region VIII, 1996-1999

PRESENTATIONS AND PUBLICATIONS

- “Maximizing the Potential for Renewable Energy, Waste-to-Energy, Maui’s Untapped Asset” presented to Maui County Energy Expo 2007, November 9, 2007.
- “Combined Heat & Power,” presented to King County/Washington State, 2005 Climate Change Conference, Seattle, Washington, October 25, 2005.
- “Combined Heat & Power Workshop,” sponsored by the Oregon Department of Energy, Oregon Public Utility Commission, and Energy Trust of Oregon, November 30, 2004.
- “Combined Heat & Power,” sponsored by the Industrial Customers of Northwest Utilities, Northwest Industrial Gas Users, March 3, 2004.
- “Comparison of High-Efficiency Distributed Cogeneration and Large Combined-Cycle Power Generation”, presented to ASME//IGTI Turbo Expo, Atlanta, Georgia, June 16, 2003
- “Siting Power Plants in the Pacific Northwest,” John R. Martin, World-Generation, September/October 2002.
- “Industrial Cogeneration – A Case Study,” presented to the Distributed Power Conference, Oregon Section, ASME International, April 2001.
- "The Economics of New Gas Turbine Resources in the Pacific Northwest," John R. Martin and F. Duncan McCaig, International Gas Turbine Institute, Cogen Turbo Power '94 Conference.
- "Evaluation of Horizontal Trenches for Landfill Gas Collection at Rossmans Landfill," Mark Fujii and John Martin, Proceedings from GRCDA 8th International Landfill Gas Symposium, April 9, 1985.
- "Fundamentals of Cogeneration," presented to Symposium on Cogeneration at the University of Florida, Gainesville, March 4, 1983.
- "Innovative Thermal Energy Systems," presented to Oregon Section of ASME, January 10, 1983.
- "Pacemaking Retrofits/Bull Run Hydroelectric Facility," John R. Martin, Electric Utility. . .1982 Generation Planbook (Power Magazine).

EXPERT WITNESS TESTIMONY AND DEPOSITIONS

Listed below are Mr. Martin's prior engagements as an expert witness. The dates indicated are approximate.

1981 – Expert witness for Great Western Malting attorneys in arbitration. No deposition taken. Testimony provided.

1991 – Expert for Babcock and Wilcox attorneys concerning the Feather River Biomass project. An expert report was prepared, but no testimony or depositions provided.

1993 – Expert for Fluor/Daniel attorneys concerning the Salt City Power Plant. An expert report was prepared for mediation. No deposition taken.

1995 – Expert for Wormser Engineering Trust attorneys concerning litigation related to the North Tonawanda Cogeneration Project. Deposition taken. No testimony provided.

2000 – Expert for Empire Energy attorneys concerning litigation related to the McDill Air Force Cogeneration Project. Expert report and testimony provided. No deposition taken.

2003 – Expert for Nooter/Eriksen attorneys concerning litigation related to a personal injury at the El Dorado Power Plant. Expert report was provided. Deposition provided. No testimony provided.

2006 – Expert for Nooter/Eriksen attorneys concerning litigation related to turbine damage at the El Dorado Power Plant. Expert report was provided. No deposition or testimony.

2006 – Expert for Travelers Insurance attorneys related to a professional liability claim. Expert report provided.

BEFORE THE PUBLIC UTILITY COMMISSION

OF OREGON

UE 196

	)
In the Matter of	)
	)
PORTLAND GENERAL ELECTRIC COMPANY	)
	)
	)
Application to Amortize the Boardman Deferral.	)
	)
	)

ICNU/102

DOCUMENTS RECEIVED AND REVIEWED BY

JOHN R. MARTIN

FEBRUARY 20, 2008

ICNU/102

Documents Received and Reviewed

1. UE 196 PGE's Responses to Data Requests by ICNU and OPUC

2. UE 196 Direct Testimony and Exhibits of Stephen Quennoz

3. UE 196 Direct Testimony and Exhibits of Alex Tooman and Patrick G. Hager

BEFORE THE PUBLIC UTILITY COMMISSION

OF OREGON

UE 196

	)
In the Matter of	)
	)
PORTLAND GENERAL ELECTRIC COMPANY	)
	)
Application to Amortize the Boardman Deferral.	)
	)

ICNU/103

EXCERPTS FROM TURBINE UPGRADE CONTRACT

REDACTED

FEBRUARY 20, 2008

January 15, 2008

TO: Melinda Davison
Industrial Customers of NW Utilities

FROM: Patrick G. Hager
Manager, Regulatory Affairs

PORTLAND GENERAL ELECTRIC
UE 196
PGE Response to ICNU Data Request 3.8
Dated December 28, 2007
Question No. 012

Request:

Please provide a copy of all contracts between Portland General Electric and Siemens for all work performed by Siemens from 2000 through June 2007. This should include but not be limited to the following:

- **Installation of the Low Pressure Turbines (LPT1 and LPT2) and any other maintenance and repairs;**
- **LP turbine bearing modifications in 2002;**
- **Spring/Summer 2004 turbine generator modifications and repairs; and**
- **Evaluation of the LP No. 1 turbine rotor failure.**

Response:

PGE objects to this request because it is overly broad and unduly burdensome. Without waiving objection, PGE responds as follows:

Attachment 012-A is an electronic copy of the contract for the low pressure turbine installation. No separate contract was written for the LP turbine bearing modification, as it was done under the warranty provisions of the contract provided in Attachment 012-A. Attachment 012-B is an electronic folder containing the various sections of the contract for turbine generator modifications and repairs. No separate contract was written for the evaluation of the LP No. 1 turbine rotor failure. Attachments 012-A and 012-B are confidential and subject to Protective Order No. 07-433 and are provided under separate cover.

BEFORE THE PUBLIC UTILITY COMMISSION

OF OREGON

UE 196

In the Matter of	)
	)
PORTLAND GENERAL ELECTRIC COMPANY	)
	)
Application to Amortize the Boardman Deferral.	)

ICNU/105

PGE RESPONSE TO

ICNU DATA REQUEST NO. 3.14

FEBRUARY 20, 2008

January 15, 2008

TO: Melinda Davison
Industrial Customers of NW Utilities

FROM: Patrick G. Hager
Manager, Regulatory Affairs

PORTLAND GENERAL ELECTRIC
UE 196
PGE Response to ICNU Data Request 3.14
Dated December 28, 2007
Question No. 018

Request:

Please provide the PGE QA/QC program that was used during all work performed by Siemens from 2000 through 2007. Does PGE utilize independent inspection of work performed by Siemens or does PGE staff provide direct inspection and approval of work performed by Siemens? Please provide all QA/QC reports and inspection reports for all work performed by Siemens from 2000 through 2007.

Response:

PGE objects to this request because it is overly broad and unduly burdensome. Without waiving objection, PGE responds as follows:

PGE required Siemens to have their own quality program and use it to identify, evaluate and resolve any nonconforming items that were found during work on the turbine. PGE plant and corporate personnel (including project and plant engineers and an ASNT certified Level III NDE examiner) provided vendor oversight. They witnessed critical steps and verified that Siemens' quality program was followed. PGE did not specifically approve or disapprove the work because Siemens is considered to be the industry expert on the Boardman turbine. Attachment 018-A is a 2000 Siemens report on turbine work performed by Siemens. See also the report material for 2002, 2004, and 2006 (submitted in response to ICNU Data Requests Nos. 009, 010, and 016).

Due to its voluminous size Attachment 018-A is provided electronically only (CD) and is confidential and subject to Protective Order No. 07-433 and is provided under separate cover.

BEFORE THE PUBLIC UTILITY COMMISSION

OF OREGON

UE 196

In the Matter of	)
	)
PORTLAND GENERAL ELECTRIC COMPANY	)
	)
Application to Amortize the Boardman Deferral.	)

ICNU/106

PGE RESPONSE TO

ICNU DATA REQUEST NO. 5.13

FEBRUARY 20, 2008

February 6, 2008

TO: Brad Van Cleve
Industrial Customers of NW Utilities

FROM: Randy Dahlgren
Director, Regulatory Policy & Affairs

PORTLAND GENERAL ELECTRIC
UE 196
PGE Response to ICNU Data Request 5.13
Dated January 22, 2007
Question No. 032

Request:

Did PGE collect the rebate of $1,600,000 from Siemens, referenced in the LP Turbine Contract? If so, please describe the accounting treatment for such amount.

Response:

PGE collected approximately $1.4 million in reduced charges for the HP/IP turbine upgrade performed by Siemens Westinghouse in 2004. Attachment 032-A contains the relevant pages of the contract for the 2004 HP/IP turbine upgrade. This attachment is confidential and subject to Protective Order No. 07-433.

There was not special accounting treatment. PGE simply paid less to Siemens for the HP/IP turbine upgrade than we would have absent the "rebate."

BEFORE THE PUBLIC UTILITY COMMISSION

OF OREGON

UE 196

In the Matter of	)
	)
PORTLAND GENERAL ELECTRIC COMPANY	)
	)
Application to Amortize the Boardman Deferral.	)

ICNU/107

EXCERPT OF PGE RESPONSE TO

ICNU DATA REQUEST NO. 1.1

FEBRUARY 20, 2008

November 5, 2007

TO: Vikie Bailey-Goggins
Oregon Public Utility Commission

FROM: Patrick G. Hager
Manager, Regulatory Affairs

PORTLAND GENERAL ELECTRIC
UE 196
PGE Response to OPUC Data Request
Dated October 22, 2007
Question No. 003

Request:

Does PGE have business interruption or consequential damage insurance for any of the thermal plants such as Boardman? If no, has PGE ever had such insurance? Please explain.

Response:

PGE does not have, nor has it ever had, business interruption or consequential damage insurance for any of the thermal plants such as Boardman. As stated in PGE's Response to OPUC Staff Data Request 014 in Docket UM 1234, "To PGE's knowledge, there are no equipment manufacturers that will enter into a contract that contains penalties for consequential damages. Discussions with suppliers have indicated that the selling prices would rise to prohibitive levels, if a sale could be negotiated, with coverage of consequential damages."

BEFORE THE PUBLIC UTILITY COMMISSION

OF OREGON

UE 196

	)
In the Matter of	)
	)
PORTLAND GENERAL ELECTRIC COMPANY	)
	)
Application to Amortize the Boardman Deferral.	)
	)

ICNU/108

PGE RESPONSE TO

ICNU DATA REQUEST NO. 5.12

FEBRUARY 20, 2008

February 6, 2008

TO: Brad Van Cleve
Industrial Customers of NW Utilities

FROM: Randy Dahlgren
Director, Regulatory Policy & Affairs

PORTLAND GENERAL ELECTRIC
UE 196
PGE Response to ICNU Data Request 5.12
Dated January 22, 2007
Question No. 031

Request:

Please describe all warranty claims that PGE has asserted against Siemens Westinghouse under the equipment warranty in the LP Turbine Contract. Also describe Siemens Westinghouse's response to such claims.

Response:

PGE objects to this request because it is overly broad. Without waiving objection, PGE responds as follows:

PGE requested four new tilt pad bearings for the LP turbines and a lift oil system under the Siemens Westinghouse warranty. Siemens installed the new tilt pad bearings and lift oil system in 2002, during a planned maintenance outage.

PGE made a warranty claim against Siemens Westinghouse for a new LP 1 rotor when the crack occurred in 2005. PGE based the claim on the warranty provision of the turbine upgrade contract, which protected PGE from "defects or faults in the Equipment arising within ten (10) years from the initial synchronization …" (See Page 57 of Attachment 012-A to PGE's Response to ICNU Request No. 012.). Siemens Westinghouse denied PGE's claim because, in Siemens' view, the root cause analyses did not support a conclusion that the turbine had defects or faults.