Oregon

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June 5, 2008

Via Electronic Filing and U.S. Mail

OREGON PUBLIC UTILITY COMMISSION
ATTENTION: FILING CENTER
PO BOX 2148
SALEM OR 97308-2148

RE: **Docket No. UE 196** - In the Matter of PORTLAND GENERAL ELECTRIC COMPANY Application to Amortize the Boardman Deferral.

Enclosed for filing in the above-captioned docket is the Public Utility Commission Staff's Surrebuttal Testimony. This document is being filed by electronic mail with the PUC Filing Center.

/s/ Kay Barnes

Kay Barnes
Regulatory Operations Division
Filing on Behalf of Public Utility Commission Staff
(503) 378-5763
Email: kay.barnes@state.or.us

cc: UE 196 Service List - parties

PUBLIC UTILITY COMMISSION OF OREGON

UE 196

STAFF SURREBUTTAL TESTIMONY OF

Ed Durrenberger

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

June 5, 2008

CASE: UE 196
WITNESS: Ed Durrenberger

PUBLIC UTILITY COMMISSION
OF
OREGON

STAFF EXHIBIT 200

Surrebuttal Testimony

June 5, 2008

Q. PLEASE STATE YOUR NAME, OCCUPATION, AND BUSINESS ADDRESS.

A. My name is Ed Durrenberger. I am a Senior Utility Analyst employed by the Public Utility Commission. I have provided Direct Testimony in this proceeding that can be found at Exhibit Staff/100/Durrenberger. My Witness Qualification Statement is found in Exhibit Staff/101.

Q. DID YOU PREPARE AN EXHIBIT FOR THIS DOCKET?

A. Yes, in addition to Exhibit Staff/102 included in my direct testimony, I am including Exhibit Staff/ 201, 202 and 203 consisting of a total of 26 pages.

Q. COULD YOU PLEASE SUMMARIZE YOUR SURREBUTTAL TESTIMONY?

A. Yes. The first part of this Surrebuttal Testimony will include my response to some of the arguments made by others in Reply Testimony. It will also include responses to PGE's Rebuttal Testimony. The second part will be a discussion and evaluation of some of the additional information that parties have uncovered on this matter since my initial Testimony. In the next part of this testimony I will summarize my position on the prudence of PGE's actions leading up to, during and after the turbine break down. Finally I will re-examine and comment on the steps that I believe should be taken to prevent a reoccurrence of the break resulting in the excess power costs.

Part I:

Q. PLEASE SUMMARIZE THE ARGUMENTS THAT OTHER PARTIES MADE IN THEIR REPLY TESTIMONY.

A. The Citizens' Utility Board (CUB) and the Industrial Customers of Northwest Utilities (ICNU) both submitted reply testimony in UE 196, the Boardman Excess Power Cost Deferral docket.

Q. CAN YOU SUMMARIZE CUB'S REPLY TESTIMONY?

A. CUB states, in its Reply Testimony, that PGE installed an untested turbine design in 2000 and that its experimental nature could have made it prone to a greater risk of failure than a standard design. CUB argues, essentially, that the company failed to adequately analyze and mitigate risks from a failure of this untested and experimental device and because of that, the failure on 2005 was the result of imprudence on the part of PGE and the excess power costs stemming from the Boardman outage are not recoverable from customers.

Q. DO YOU AGREE WITH CUB'S TESTIMONY?

A. Not entirely. I do agree with CUB's characterization that the turbine upgrade in 2000 was a new design in that it incorporated new and different rotating elements and casing liners. I also believe that any new installation of a large rotating machine such as this carries a certain risk from problems that arise in the initial start-up and operational period. I disagree that no attempt was made to mitigate risks. PGE secured an uptime guarantee from the manufacturer for the first year of operation and negotiated with the vendor to hold a supply of specialty spares unique to this machine. The company has indicated (*See*

Exhibit Staff/ 202, Exhibit 1) that consequential damage insurance is not and has not been a viable cost mitigation strategy for their thermal facilities. I think it reasonable to conclude, as the company evidently did, that any sort of technological risk that may have resulted from the new design and installation would have been revealed in a relatively short time. I am not convinced that the failure that occurred five and one half years after startup had anything to do with whether the actual higher-efficiency design was untested or not. Nor am I convinced that PGE failed to take adequate measures to mitigate the risks of an untested new installation at the time of the initial startup and operation.

Q. WHAT IS ICNU'S POSITION ON THE BOARDMAN EXCESS POWER COST DEFERRAL AMORTIZATION?

A. The ICNU reply testimony also recommends that the Commission not allow PGE to recover any of the excess power costs it deferred. Although they took issue with the completeness of the root cause analysis reports provided by the company, ICNU cites a number of factors, some of which are failures on the part of the original equipment manufacturer (OEM), which led to the failure. ICNU believes that PGE is at fault because it participated in buying the new, untested design and did not have consequential damage insurance to cover power costs in case of a failure. In addition ICNU testified that PGE should have had better quality assurance and quality control over the OEM's installation and maintenance of the unit and, once a problem had arisen, pursued the OEM more vigorously for warranty claims.

Q. WHAT IS YOUR OPINION ABOUT THE POINTS THAT ICNU RAISES?

A. I, also, was not entirely happy with the conclusions of the company's RCAs and I did draw some of the same conclusions as ICNU regarding the OEM. The OEM designed, installed and maintained the turbine, so once it was established that the crack was not the result of an operating problem under PGE's direct control, it became a failure in one of these three categories, each under OEM control. I dispute ICNU's assertion that PGE should not have participated in buying and installing a generator that was four percent more efficient that the previous machine. I assert that it would be imprudent to not pursue cost effective efficiency improvements, especially on what are supposed to be a long lived assets like a turbine. As I discussed earlier, some reasonable risk mitigation steps were taken by the company during the first year of operation. And consequential damage insurance doesn't appear to be a viable mitigation tool for utility scale thermal plants. ICNU's conclusion that turbine maintenance and installation quality assurance and quality control was lacking seems true but I have not concluded that the omission was on the part of the PGE O&M team who arguably hired the best outfit they could to install and maintain this critical piece of equipment. In summary, I agree with many of the individual ICNU raises but do not reach the same conclusion as ICNU.

Q. PLEASE SUMMARIZE PGE'S RESPONSE TO REPLY TESTIMONY FROM STAFF AND OTHER PARTIES.

A. First I will discuss PGE's response to Staff Testimony, and then I will look at the company responses to CUB and ICNU's testimony.

Q. DID PGE DISAGREE WITH STAFF'S TESTIMONY?

A. To some extent, yes. Although the company did not disagree with my prudence findings, PGE did disagree with my assessment of the probability of a reoccurrence of this event. I asserted that the rotor integrity may be compromised by it having been parted and re-welded back together and that accordingly, there seemed to be a heightened possibility of a reoccurrence. If the shaft were to crack again in the same sort of time frame and under the same sort of circumstances, it would look more like something that happens in a predictable stochastic way and cost recovery through a deferral could be a lot less certain. Whether PGE could obtain cost recovery for a future failure of the rotor like that experienced in 2005 is a matter for the Commission to decide in a future docket, but I wanted the company to evaluate the affordability of a spare rotor or some other power cost hedge with my observations in mind.

Q. WHAT DID PGE PROPOSE INSTEAD?

A. The company proposed a number of measures, all of which I would classify as heightened oversight and inspection measures. For instance they now intend to more intensively inspect the crack location. They also plan to use an outside consultant to monitor alignment and vibration and will be examining other spots on this and other Boardman turbines shafts for problems.

Q. DO YOU CONSIDER THAT SUFFICIENT?

A. The company's increased vigilance should help spot a problem before it leads to an immediate shutdown. But I fail to see how, if there is some combination of mechanisms at work as the RCA indicates, cracking will not reoccur and if another crack is detected, how it could necessarily be scheduled to be fixed at a time when market power costs are at or below Boardman generation costs.

Q. WHAT DID PGE HAVE TO SAY ABOUT CUB'S REBUTTAL TESTIMONY?

A. PGE did not subscribe to CUB's characterization of the turbines as experimental. The company made a distinction that the only thing experimental about the upgrade was the last row blades, a feature that was not involved in the failure under discussion here. This was a distinction that, to my knowledge, parties had not aware of up until this point. PGE also restated the risk mitigation steps it took with the turbine upgrade and discussed the relative cost savings from the increase in efficiency that far out-weighed the excess power costs from the break down.

Q. DID PGE FAIL TO ADDRESS ANY OF CUB'S ASSERTIONS?

A. PGE adequately addressed the issues raised in CUB's Reply testimony.

Q. WHAT DID PGE HAVE TO SAY ABOUT ICNU'S REPLY TESTIMONY?

A. PGE agreed with ICNU that they were not negligent in their operation of the Turbine. Beyond that, the company took issue with ICNU's every assertion -- including ICNU's characterization of the upgrade as experimental and ICNU's criticisms of the mitigation measures PGE took, the quality assurance program the company has, and the completeness of the RCAs. PGE testified to a spotless record of exemplary operation and maintenance of the Boardman turbine.

Q. DID PGE'S REBUTTAL OF ICNU TESTIMONY ADDRESS ALL OF THE ISSUES ICNU RAISED?

A. I believe it did.

PART II:

Q. IS THERE ADDITIONAL INFORMATION THAT YOU WOULD LIKE TO DISCUSS?

R. Yes, ICNU has persistently pursued a line of questioning through data requests to the company seeking to discover if there is one or more other root cause analysis reports that the company commissioned but has not provided to parties.

Q. WHAT IS THE OUTCOME OF THIS LINE OF QUESTIONING?

A. PGE has denied having any additional RCA reports on the turbine rotor cracking problem. The company did provide parties with another root cause analysis report on a separate later outage caused when the generator rotor was damaged (*See* Exhibit Staff/ 203). This other RCA concerns an incident that the company is not bringing to the commission for rate relief on and is not directly associated with UE 196.

B. **STAFF INITIALLY INQUIRED ABOUT ANY LEGAL ACTION THAT PGE HAS INITIATED CONCERNING THIS BREAK DOWN (*SEE* EXHIBIT STAFF/102 PAGES 1 AND 2). HAS THERE BEEN ANY LEGAL ACTION INITIATED BY PGE OR OTHER PARTIES SINCE THAT TIME?**

A. Yes, Turlock Irrigation District, an assignee of some of the Boardman power output not owned or controlled by PGE, has filed a suit in the Municipal Courts seeking to recover excess power costs that were incurred during both the initial outage from the turbine shaft cracking and for a later outage not associated with this docket (*See* Exhibit Staff/ 202, Exhibit 2)

Q. DOES THIS LEGAL ACTION AFFECT ANYTHING THAT IS CURRENTLY UNDER REVIEW IN THIS DOCKET?

R. I do not know, that would be a matter for counsel to evaluate. I know that I would be interested in reviewing any recommendation I am making now regarding the prudence of PGE's actions in this docket, were new information to be uncovered in the court preceding.

Q. ARE THERE ANY OTHER NEW PIECES OF INFORMATION THAT YOU WOULD LIKE TO DISCUSS AT THIS TIME?

A. No.

PART III:

Q. WHAT DO YOU CONCLUDE?

R. I believe PGE has demonstrated that it operates the Boardman Turbine in accordance with the manufacturer's procedures. I believe it is a wise decision to have the original equipment manufacturer perform major maintenance to the turbine. I conclude that PGE's operation and maintenance of the Boardman turbine was not imprudent and shows a careful consideration of the circumstances and possible consequences of their actions related to this machine.

Q. HAS THE ADDITIONAL TESTIMONY AND FACT FINDING CHANGES YOUR EVALUATION OF THE BREAKDOWN?

R. With respect to PGE's direct oversight of their turbine maintenance, I see that the company has proposed a number of improvements that would perhaps spot a problem developing at an earlier stage. This additional "belt and suspenders" action leads me to believe that the company maintenance oversight for this machine was inadequate or at least lax. I believe that OEM maintenance should not require a significant amount of oversight but this incident seems to indicate differently.

PART IV:

Q. ARE THERE ANY OTHER ISSUES YOU WOULD LIKE TO DISCUSS?

R. Yes. I remain concerned that since the actual cause of the cracking was not determined and the only remedies currently in place for further cracking is a more frequent and detailed inspections of the shaft, this event could happen again with the same or greater excess power cost consequences. In my direct testimony I suggested the company look into either a replacement shaft or some other hedge that would mitigate the financial risk of another prolonged repair shutdown. I encourage PGE to rethink if their proposed plans for the future are all they should do. I further hope the Commission would see that it would be in customer's interests for PGE to do more than their "shutting the barn door after the horse is out".

S. DO YOU HAVE ANY FURTHER COMMENTS?

A. No. That concludes my testimony.

CASE: UE 196
WITNESS: Ed Durrenberger

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STAFF EXHIBIT 201

Exhibit in Support
of Surrebuttal Testimony

June 5, 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."

CASE: UE 196
WITNESS: Ed Durrenberger

PUBLIC UTILITY COMMISSION OF OREGON

STAFF EXHIBIT 202

Exhibits in Support of Surrebuttal Testimony

June 5, 2008

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IN THE CIRCUIT COURT OF THE STATE OF OREGON

FOR THE COUNTY OF MULTNOMAH 12156

TURLOCK IRRIGATION DISTRICT, Plaintiff, v. PORTLAND GENERAL ELECTRIC COMPANY, Defendant.	Case No. 0710-12156 **COMPLAINT FOR BREACH OF CONTRACT, NEGLIGENCE AND GROSS NEGLIGENCE** (Claim Not Subject to Mandatory Arbitration)

Plaintiff Turlock Irrigation District ("Turlock") alleges as follows:

INTRODUCTION

1. Turlock is an irrigation district organized and existing under the constitution of the State of California and Division 11 of the California Water Code. Since 1923, Turlock has provided safe, low-cost and reliable electric service to a community that includes approximately 97,000 home, farm, business, industrial and municipal accounts.

2. Turlock purchases electric power and capacity from the Boardman Generating Plant ("Boardman"), among other sources. Boardman is a 600 megawatt coal-fired electric generating facility located in Morrow County in the State of Oregon.

3. Defendant Portland General Electric Company ("PGE"), Power Resources Cooperative ("PRC") and Idaho Power Company ("Idaho Power") each hold title to Boardman in the form of undivided interests as tenants in common. PRC has assigned Turlock certain of PRC's rights and obligations with respect to power generated at Boardman.

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ORIGINAL

4. Boardman is operated and maintained exclusively by PGE. PGE is an Oregon corporation with its headquarters and principal place of business located in Multnomah County, Oregon.

5. According to its own independent consultants, PGE committed a series of clear, egregious errors in its operation and maintenance of Boardman, resulting in two foreseeable, extended outages between October of 2005 and April of 2006 ("Outages"). The Outages also caused significant increased operation and maintenance costs at Boardman.

6. As a direct result of the Outages, Turlock was forced to undertake costly measures to locate and secure a replacement power supply. Turlock incurred approximately $14,434,000 in additional expenses to obtain the replacement power. This lawsuit seeks to redress this and other harm suffered by Turlock as a direct result of PGE's failure to properly operate, maintain, and repair Boardman.

FACTS COMMON TO ALL CAUSES OF ACTION

Turlock is Contractually Entitled to Schedule and Receive Energy from Boardman

7. PGE, PRC and Idaho Power each are parties to an Agreement for Construction, Ownership and Operation of the Number One Boardman Station on Carty Reservoir, dated October 15, 1976, as amended ("Ownership Agreement"). At the time the Ownership Agreement went into effect, PRC was organized as the Pacific Northwest Generating Cooperative.

8. Pursuant to Section 2(a) of the Ownership Agreement, PRC and Idaho Power each hold an Ownership Share in Boardman of ten percent (10%) and PGE owns the remaining eighty percent (80%).

9. Pursuant to Section 12 of the Ownership Agreement, PRC has the right to schedule and receive the net capacity and energy ("Output") of Boardman in an amount equivalent to the percentage of its Ownership Share. "Scheduling" occurs when a party places an order for a specific amount of energy or capacity to be made available at a certain place and

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time.

10. On or about November 10, 1992, pursuant to the terms of a Power Purchase Agreement ("PPA"), PRC assigned to Turlock the right to schedule and receive its Ownership Share of power generated at Boardman. Section 2(d) of the PPA provides:

> The Parties acknowledge that [PRC] is assigning to Turlock those [PRC] rights and privileges [PRC] holds pursuant to the Ownership Agreement set forth in this Agreement, but that any of [PRC's] rights and privileges regarding the Project not expressly assigned to Turlock pursuant to this Agreement are retained by [PRC].

Section 9(a) of the PPA provides that PRC, on Turlock's behalf, will "schedule power in accordance with Turlock's instructions." Section 9(d) of the PPA states that "Turlock shall schedule and take [PRC's] Ownership Share of any Project minimum generation or test generation."

11. PGE never objected to PRC's partial assignment of rights under the Ownership Agreement to Turlock. Since the effective date of the PPA in 1992, PGE has at all times scheduled PRC's Ownership Share of Boardman Output as directed by Turlock.

12. In addition to being a partial assignee of PRC's right to schedule and receive the Output under the Ownership Agreement, on or about August 21, 2007, PRC executed another Agreement with Turlock by which PRC assigned whatever additional rights, claims or causes of actions PRC may have against PGE arising out of the Outages ("Assignment Agreement"). Section 2 of the Assignment Agreement provides in relevant part:

> PRC hereby assigns to TID all rights, claims, or causes of action, choate or inchoate, that it now has under the Ownership Agreement and/or under any applicable law to obtain a recovery of damages against PGE for the damages that TID claims it has suffered as described in TID's letter of January 9, 2007, and any other rights, claims, or cause of action that PRC had, now has, or may acquire in the future, known or unknown, against PGE or any other person.

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The Ownership Agreement Requires PGE to Operate and Maintain Boardman According to the Prudent Utility Practice Standard and to Ensure Adequate Staffing and Engineering

13. PGE is the sole and exclusive operator of the Boardman plant. Section 8 of the Ownership Agreement requires PGE to operate and maintain Boardman according to "Prudent Utility Practice":

> PGE shall carry out operation and maintenance of the Project so as to meet the requirements of government agencies having jurisdiction in the matter, in accordance with Prudent Utility Practice, giving due consideration to the recommendations of the Operating Committee and to the manufacturers' warranty requirements. Subject to the forgoing and to the provisions of Section 12, PGE shall operate and maintain the Project so as to produce the amounts of energy scheduled by the Parties within their respective Ownership Shares of the net capacity of the Generating Plant.

14. Section 1(m) of the Ownership Agreement defines the Prudent Utility Practice standard as follows:

> "Prudent Utility Practice" means any of the practices methods and acts engaged in or approved by a significant proportion of the electrical utility industry prior to the time of the reference, or any of the practices, methods and acts which, in the exercise of reasonable judgment in light of the facts known at the time the decision was made, could have been expected to accomplish the desired result at the lower reasonable cost consistent with reliability, safety and expedition. Prudent Utility Practice shall apply not only to functional parts of the Project but also to appropriate structures, landscaping, painting, signs, lighting and other facilities and public relations programs reasonably designed to promote public enjoyment, understanding and acceptance of the Project. Prudent Utility Practice is not intended to be limited to the optimum practice, method or act to the exclusion of all others, but rather to be a spectrum of possible practices, methods or acts.

15. In addition, Section 22 of the Ownership Agreement specifically obligates PGE to "carry out a familiarization and training program to maintain adequate staffing, engineering and operation of the [Boardman plant]."

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<u>PGE's Manifest Failures to Adhere to Prudent Utility Practice and Ensure Adequate Staffing and Engineering Caused the Outages</u>

16. On or about October 23, 2005, the Outages began with the discovery of a crack in Boardman's turbine generator shaft. PGE took the generator off-line in order to repair the shaft.

17. PGE commissioned an independent engineering consultant to perform an analysis and prepare a report addressing why the turbine generator shaft cracked. PGE has refused to provide the engineering consultant's report to Turlock. On information and belief, Turlock alleges that the crack in the turbine generator shaft was caused by PGE's failure to properly operate and maintain Boardman in accordance with Prudent Utility Practice. On information and belief, Turlock further alleges that the crack in the turbine generator shaft was caused by PGE's failure to ensure the adequate staffing, engineering and operation of Boardman

18. On February 5, 2006, in an effort to bring Boardman back on-line following repairs to the turbine generator shaft, PGE caused a generator failure that further extended the Outages.

19. PGE commissioned another independent engineering consultant, Pilot Advisors, to investigate the cause of the second failure. Pilot Advisors detailed its findings in a document known as the 2006 Generator Failure Independent Root Cause Investigation, dated July 25, 2006 ("Root Cause Investigation"). A copy of the Root Cause Investigation is attached and incorporated by this reference, marked Exhibit 1.

20. According to the Root Cause Investigation, Torque Strain Relay units ("Relay Units") were to be installed before the generator was brought on-line after the first Outage. The Relay Units were intended and necessary to protect the turbine generator shaft from sustaining future damage or cracks. PGE failed to install the Relay Units before initiating the start-up process. The generator was started and brought on-line before PGE discovered the missing Relay Units.

21. Once discovered, PGE recognized that the missing Relay Unit error had to be remedied. However, in order to install the forgotten Relay Units, it was necessary for PGE to

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take the generator back off-line and slow the turbine to a near-stop. This process is extremely complicated and required careful attention by PGE. During the process, PGE's management allowed the Control Operator, whom PGE knew had past performance problems and inadequate training, to remain at the controls.

22. Twenty-two minutes after the generator was taken off-line, and for the next several minutes, no less than three *different* alarms triggered. The first alarm was a generator frequency alarm, which alerted PGE's Boardman operators to a significant abnormal condition.

23. The second and third alarms indicated specific problems with the exciter, a critical component of the generator. Boardman procedures require the exciter to be manually tripped in order to prevent it from supplying electric current (and resulting heat buildup) to the generator in the event that the generator slows or stops. Boardman's controls previously contained an automatic tripping mechanism for the exciter. This automatic tripping mechanism was removed from Boardman's controls in 1997 when PGE upgraded the control systems. PGE was well aware that the absence of any automatic mechanism required manual tripping of the exciter. When the second and third alarms sounded, the generator had been intentionally slowed, but PGE's operators had failed to manually trip the exciter. The alarms sounded because of this error.

24. PGE's operators failed to investigate, analyze or otherwise respond to any of these three alarms. Instead, PGE's operators continued the process of installing the missing Relay Units. As the installation proceeded, the still-active exciter caused dangerous and excessive heat to build up in the generator.

25. Boardman procedures also require Relay Units to be installed using a hazardous energy control procedure. The purpose of the procedure is to protect plant personnel from injury by removing all potential energy sources from the area, such as the energy being supplied by the exciter. PGE's operators also failed to follow this procedure.

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26. Because the exciter was still active and providing electric current to the work area, PGE's workers installing the Relay Units reported electricity arcs and the dimming of plant lights when they began installation work. The Control Operator also noticed the electricity arcs. These observations should have been investigated as part of PGE's hazardous energy control procedure. An investigation would have led to the discovery of the still-operating exciter.

27. Approximately one-and-a-half hours after Boardman was taken off-line, two more alarms sounded within five minutes of each other. Both alarms warned of signified abnormal heating in the generator. PGE's operators failed to investigate either of these two additional alarms.

28. The exciter was not manually tripped until more than ***9 hours after*** Boardman was taken off-line, following a shift-change of personnel—including a different Control Operator. The time that lapsed before the exciter was finally tripped allowed dangerous and excessive heat to build up in the generator, directly resulting in severe damage to the generator.

29. The factual investigation and conclusions set forth in the Root Cause Investigation leave no doubt that PGE's numerous errors violated PGE's own policies and procedures, and were a clear breach of the Prudent Utility Practice standard required by the Ownership Agreement.

30. The conclusion set forth in the Executive Summary of the Root Cause Investigation reads as follows:

> The failure of the generator was the direct result of management failing to ensure critical personnel remain qualified to properly operate the assets. Contributing causes included but are not limited to the [PGE] design engineers [sic] (1996-1997) failure to ensure the exciter low speed trip logic was included in the change over to the DCS system and below expectations performance in other important activities.

31. According to the Root Cause Investigation, PGE management at Boardman also did not address known performance problems in a timely manner, which allowed a Control Operator with past performance problems to conduct critical plant operations, ultimately

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resulting in the generator failure.

32. The Root Cause Investigation further states that review by PGE's engineers during the design of Boardman's new controls failed to note the design change that omitted the automatic tripping mechanism of the exciter field circuit. Following the design phase, PGE had another chance to include an automatic tripping mechanism when PGE replaced the exciter in 2004, but failed to make that addition.

PGE's Repeated Failures to Maintain and Operate Boardman Caused Turlock Direct Monetary Damages

33. Pursuant to the terms of the Ownership Agreement as partially assigned to Turlock, Turlock is obligated to pay a portion of the repair costs necessitated by PGE's failure to adequately maintain and operate Boardman. Turlock estimates those costs to be in excess of $800,000.

34. The Outages also forced Turlock to find and secure a source of replacement power for the duration of the Outages. Turlock was forced to incur replacement power costs in the amount of approximately $14,434,000.

CAUSES OF ACTION

FIRST CAUSE OF ACTION

(Breach of Contract)

35. Turlock re-alleges and incorporates by reference paragraphs 1 through 34 as if fully set forth herein.

36. Turlock is a partial assignee of PRC's right to schedule and receive power under the Ownership Agreement. Turlock is entitled to directly enforce those provisions of the Ownership Agreement related to the scheduling and delivery of power—including Section 8 and Section 22.

37. PGE is contractually required by Section 8 of the Ownership Agreement to maintain and operate Boardman consistent with Prudent Utility Practice.

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38. PGE breached Section 8 of the Ownership Agreement by failing to comply with Prudent Utility Practice, including but not limited to:

A. Failing to install the Relay Units;

B. Failing to respond to the generator alarms;

C. Failing to respond to two different exciter alarms;

D. Failing to implement and follow an adequate hazardous energy control procedure;

E. Failing to investigate electrical arcing during installation of the Relay Units;

F. Failing to investigate two additional heat alarms; and

G. Failing to manually trip the exciter for more than 9 hours after the initial alarms had sounded.

39. PGE is required by Section 22 of the Ownership Agreement to implement an appropriate training program. PGE breached Section 22 of the Ownership Agreement by failing to provide proper training to, and exercising appropriate control over, its operators.

40. PGE's breaches of the Ownership Agreement resulted in direct monetary damages to Turlock in an amount to be proven at trial but not less than $15,233,000.

41. Turlock and PRC have each performed all of their respective obligations under the Ownership Agreement, including but not limited to remitting timely payment to PGE for the operation and maintenance of Boardman.

SECOND CAUSE OF ACTION

(Negligence)

42. Turlock re-alleges and incorporates by reference paragraphs 1 through 41 as if fully set forth herein.

43. PGE knew that Turlock was relying on PGE to operate and maintain Boardman in a prudent and workmanlike manner. It was foreseeable to PGE that any failure to do so on its part would cause direct harm to Turlock.

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44. PGE was negligent in connection its operation and maintenance of Boardman.

45. PGE's negligent conduct could have been prevented through use of well-established engineering and management practices, and through implementation of PGE's own policies.

46. PGE's conduct directly resulted in damages to Turlock in the form of harm to Turlock's property interests and increased costs in an amount to be proven at trial but not less than $15,233,000.

THIRD CAUSE OF ACTION

(Gross Negligence)

47. Turlock re-alleges and incorporates by reference paragraphs 1 through 46 as if fully set forth herein.

48. PGE was reckless and otherwise grossly negligent in its operation and maintenance of Boardman.

49. PGE's gross negligence directly resulted in damages to Turlock in the form of harm to Turlock's property interests and increased costs in an amount to be proven at trial but not less than $15,233,000.

WHEREFORE, plaintiff Turlock prays for a judgment against defendant PGE as follows:

1. For an amount not less than $15,233,000, plus Turlock's costs and disbursements incurred herein; and

2. For such further relief as this Court may deem just and proper.

DATED this 19th day of October, 2007.

CABLE HUSTON BENEDICT HAAGENSEN & LLOYD LLP

[signature] for

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Boardman Plant

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Date 8/4/06

2006 Generator Failure
Independent
Root Cause Investigation
Event Date: 2/5/2006

CASE: UE 196
WITNESS: Ed Durrenberger

PUBLIC UTILITY COMMISSION OF OREGON

STAFF EXHIBIT 203

Exhibits in Support of Surrebuttal Testimony

June 5, 2008

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I. Executive Summary:

Purpose:

Pilot Advisors, Inc., was retained by Portland General Electric to independently identify the root cause(s) of the events and actions leading to severe damage to the Boardman Plant's main generator and the subsequent loss of its ability to generate power for an extended period of time beginning on February 5, 2006. The analysis has been completed and documented in this report.

The analysis was performed using methodologies recognized as best practices in the investigative and root cause analysis fields. The primary tools included Events and Causal Factors, Energy-Target-Barrier and Failure Mode Analyses. The process required extensive interviewing and subsequent verification and validation of any anecdotal evidence. The result is a comprehensive and intentionally independent account of what happened and why it happened, enabling PGE to take actions to prevent the recurrence of similar unwanted events.

Event Synopsis:

In the days preceding February 5, 2006, Boardman Plant was recovering from a forced outage caused by generator turbine shaft cracking. By midnight on February 5th the boiler was steaming, most of the critical restart duties had been performed, and extra plant staff and management had gone home to recover from extended work hours. The main function left to be performed was turbine overspeed trip testing which is a normal test. After successful completion of that test, the plant was to be placed back on line.

On February 5, 2006 at 2207, after warming the turbine at low power output for several hours, Crew 2 opened the generator output breaker in order to perform turbine overspeed trip testing. The Control Operator (CO) failed to open the Field Circuit breaker at this time. This omission resulted in field excitation occurring during periods when the turbine-generator was turning slowly or periods when it was stopped. This excitation on the slowly turning or stopped generator shaft resulted in overheating and severe generator damage.

Conclusions:

The failure of the generator was the direct result of management failing to ensure critical personnel remain qualified to properly operate the assets. Contributing causes included but are not limited to the design engineers (1996-1997) failure to ensure the exciter low speed trip logic was included in the change over to the DCS system and below expectations performance in other important activities. Please see the detailed report below for more specifics.

II. Failure Scenario:

In 1997, Boardman upgraded and consolidated several of the modular control systems into a single Distributed Control System (DCS). This was performed by Burns & McDonnell, under the design management of PGE corporate engineering. The modular systems included major plant computer systems, including the Westinghouse turbine-generator control called DEH, the plant computer data acquisition and the boiler analog computer system.

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During this process the existing automatic low speed trip (exciter field breaker trip on generator breaker open and low turbine speed) logic used to protect the generator rotor from exciter over power damage was omitted from the DCS. There was no record found of a request by plant personnel for engineering to address the lack of the automatic safety function, nor any indication of recognition that the automatic function was absent.

The dynamic exciter was replaced with a Cutler Hammer static exciter in 2004. This static exciter differed from the original dynamic exciter in that instead of being powered by rotation of the turbine generator shaft, it was continually powered by silicon controlled rectifiers from an auxiliary power source. This increased the risk of damage to the generator because power was now available to the exciter field independent of the turbine generator speed.

In late 2005 the turbine generator shaft cracked and resulted in an extended plant outage. On February 5, 2006, while re-starting the unit following the turbine repairs, site management established a heightened level of criticality and awareness and was actively involved in critical operations through the shift change (the plant manager and others were catching sleep in their offices between critical activities). Management staff made initial observations of the start-up testing activities after a shift change from Crew 3 to Crew 2 at 1900 hours, knowing that Crew 2 was the least effective of the crews, including the first overspeed test. However, believing that the most critical startup activities had been completed and that Crew 2 appeared to be performing properly (procedures in hand), the extra support and management staff left to get necessary rest around midnight on February 5th.

On February 5, 2006 at 2207, Crew 2 opened the generator output breaker in preparation for performing turbine overspeed trip testing. However, contrary to plant operating procedures and operator training, the Control Room Operator failed to open the exciter field breaker when he opened the generator output breaker. The procedural requirement to manually open the exciter field breaker was discussed between the operator and the shift supervisor and ultimately they decided that manual action was not necessary.

Failure to open the exciter field breaker left the generator field energized and producing heat. Hydrogen cooling flow, which is dependent upon rotation of the generator shaft, decreased as the rotational speed of the turbine decreased following the overspeed trip. With loss of hydrogen cooling flow, the energized generator field overheated and was severely damaged.

In addition to the critical error of not opening the exciter field breaker as required by procedure and training, their was little or no operator response to the multiple exciter/generator related alarms, or by other personnel to the sparking and lights dimming observed during the event.

Please see the Events and Causal Factors Chart, the Detailed Discussion, and/or the Chronology below for the specifics of this analysis.

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III. Root Causes and Contributing Factors:

Root Causes: The failure of the generator was the direct result of management failing to ensure critical personnel remain qualified to properly operate the assets. This led to ineffective supervision and accountability for performance, ultimately allowing personnel that were not qualified to perform critical activities.

1. Management methods did not verify that the crew was qualified to make proper decisions regarding the protection of the plant's mission critical asset, they did not recognize that the failure to open the exciter breaker would cause extensive generator damage.
   - The CO and Shift Supervisor knew that the exciter field breaker was closed but did not respond properly to the annunciator alarms and perform actions to remove the generator field excitation power by tripping the exciter field breaker.
   - The multiple alarms related to generator and exciter abnormal conditions were not investigated, analyzed, and responded to by the operating crew.
2. Management methods did not address known performance problems in a timely manner; allowing the CO with past performance issues to remain as a control room operator and to conduct critical plant maneuvering, ultimately resulting in inadequate work practices and the generator failure event.
   - Crew 2 CO neglected to follow the simulator-based and lesson-plan based training requirements to manually trip the exciter field breaker, therefore causing the generator failure event.
   - The CO failed to follow plant procedure by not manually opening the exciter field breaker following the generator output breaker trip, thus causing the subsequent generator failure..
   - There is no formal, objective, consistent re-qualification or performance monitoring process in place to ensure qualifications are maintained or enhanced as plant operations require. This lack of objective assessment has perpetuated personnel performance issues in the past and has not been resolved by management.

Contributing Factors

1. The Shift Supervisor failed to require the CO to operate the equipment in accordance with the training and procedures.
2. The failure to comply with the Lock Out/Tag Out, or hazardous energy control procedure, on the TSR relay unit installation job was a missed opportunity to limit generator damage as it would have resulted in de-energization of all dangerous sources of energy, including the exciter field.
3. Engineering review during design (1996-1997) did not catch the design change that omitted the exciter low speed trip logic in the DCS, which could have prevented this event. This was also missed again in the exciter replacement project (2004), another opportunity for engineering to identify the oversight and prevent the event.

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4. Inadequate work planning permitted the startup of the turbine generator without installing the necessary TSR instrumentation, which was a reason for stopping the turbine after testing.

5. The operating procedures contained administrative errors and human error traps that could have led to confusion on the part of a CO working at the procedural response level.

IV. Extent of Condition Assessment:

Extent of Condition/ Transportability

This incident was caused by inattention to detail on several diverse levels. An important automatic self protection feature, the automatic exciter low speed field breaker trip was removed from the Boardman Plant and not reinstalled by several PGE engineering groups and their engineering consultants, despite independent opportunities to realize this shortcoming. Inattentive work planning allowed the TSR units to be missed in the re-start, requiring (in addition to other factors) the Boardman Plant turbine generator to be shut down and stopped for their installation, thereby setting up the actual condition for shaft damage with the powered exciter field.

Control room qualified operators not only failed to properly follow plant operating procedures, but authoritatively and incorrectly stated that important directions to properly operate the exciter field breaker were omitted from those very procedures.

Control room qualified operators, incorrectly assuming the exciter field breaker would automatically trip, either failed to return their attention to the breaker position or assumed that it would automatically trip beyond the 2 hours and 32 minute time duration between when they last placed the turbine generator on the turning gear and their shift change.

These types of events are commonly characterized by near misses and precursor events. The conditions leading up to this event spanned contracts, vendor engineering expectations, corporate engineering, plant engineering, and maintenance and operations, over the course of nine years, including two major projects and a high visibility plant outage. An effective performance monitoring and trending program, often referred to as a corrective action program, would likely have offered opportunities to identify the pending major event.

V. Detailed Discussion

The Boardman Plant generator was severely damaged resulting in a major repair and extended forced outage. This generator failure event was preventable.

Crew 2 was responsible for the health and safety of the plant, its systems, and staff at the time of the event. Control room operations staff are specifically selected and trained to operate the Boardman Plant, initially becoming qualified and undergoing an oral board and testing. Once qualified, no re-qualification program exists for the control room operators. The crews undergo periodic formal simulator training, but nothing exists to ensure that they remain at the same level of plant operating knowledge they attained in their initial qualification as control room operators.

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The Control Operator (CO) on-shift at the time of the event had a history of performance issues, including less than adequate participation in biannual simulator training, which was known to the Boardman Plant management. He was initially control room qualified 26 years ago, and had been a CO for 14 years at the time of the event. He had previously declined participation during biannual simulator training.

The Boardman Plant General Manager clearly understood the importance and complexity of the plant restart. It was being restarted after an extended and expensive outage to repair the severely cracked turbine rotor. The General Manager was in the control room with the previous shift observing and providing direction as necessary as well as overseeing the operating crew involved in this event until he left to rest.

A root cause of this event is that management methods did not address known problems in a timely fashion allowing the CO with performance issues to remain as a control room operator conducting critical plant evolutions.

Several Boardman Plant qualified control room operators and plant managers were interviewed. They made it clear that they are trained biannually to operate the Plant on a simulator in Craig, Colorado. Although the simulator is not perfectly identical to the Boardman Plant, the operation of the exciter is sufficiently similar and the staff does teach the correct operation of the Boardman Plant exciter and the exciter field breaker.

Lesson Plan LP-5-1D, Turbine Generator Unit (Exciter System), is a 17 page document that describes the operation of the Boardman Plant exciter. It includes a statement that it takes precedence over the Cutler Hammer vendor manual[1]. Management passed this document to all control room crews for personal discussion and training. LP-5-1D, page 11, under **Exciter Start and Stop Control**, states:

> "Normally, after the main generator breaker has been opened, the operator manually stops the exciter during a unit stop by executing the DCS "exciter stop" command. The exciter can also be stopped (tripped) from the exciter touch-screen computer. Interlocks prevent the exciter from being stopped from the DCS or exciter touch-screen computer if the unit breaker is closed."

Additionally, page 17 of LP-5-1D under **Operating Procedures, Shutdown** states:

> "Trip the exciter from the DCS after the main generator circuit breaker has been opened."

Page nine of LP-5-1D, in a Caution Statement for the collector ring assembly, states:

> "Caution: The collector rings will quickly overheat and be damaged if excitation current is applied to them when the generator is not rotating. The exciter should not be started unless generator speed is near it [sic] normal speed of 3600 rpm."

After tripping the generator, by opening its output breaker and tripping the turbine by closing its steam stop valves, the turbine generator enters a coast down condition where the spinning turbine

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[1] LP-5-1D, page 11

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generator shaft slows and comes to a stop. When stopped, the turbine generator shaft is placed on the turning gear for a controlled slow rotation to keep it from developing a bow or warping.

During turbine generator coast down, the Crew 2 CO noticed that the exciter field breaker was still closed, feeding excitation power to the tripped generator. The Crew 2 CO asked the Crew 2 Shift Supervisor if the exciter field breaker was supposed to be open because of the "new" Cutler Hammer static exciter system. They decided that the breaker being closed was acceptable because there was not excessive voltage on the exciter. Additionally, the Crew 2 Shift Supervisor believed that with the new static exciter, during an actual turbine trip such as they were experiencing, the exciter decreased field power before it automatically tripped the breaker, and it must have been in the process of decreasing its field power before being tripped. The Crew 2 Shift Supervisor believed that the exciter field breaker always automatically opened and tripped itself in the past, so he understood the plant indications to mean that the exciter field breaker was in the process of automatically tripping itself.

In reality, there was no automatic trip of the exciter field breaker. This feature was inadvertently removed in a 1997 modification when the many computer modules were combined into the DCS system.

Between 1997, when the automatic trip feature of the exciter field breaker was inadvertently left out of the DCS, and 2004, when the dynamic exciter was replaced by a static exciter, the generator was protected by the inherent physics of the dynamic exciter. The dynamic exciter must be spinning relatively fast on the turbine generator shaft in order to provide sufficient power to excite the generator field. The stopped turbine generator shaft would make no exciter field power even with a closed exciter field breaker. When the generator was tripped with the exciter field breaker still closed on a dynamic exciter, the exciter field power would drop off with turbine shaft coast down. When it slowed to some point, the power being produced would, for all practical purposes, drop as if the breaker had tripped.

Operationally, the static exciter installed in 2004 is identical to its predecessor, the dynamic exciter. From the DCS operator control console, the operator pushes the same trip function to manually trip the static exciter field breaker as was the dynamic exciter field breaker. Mechanically and electrically, the static exciter differs tremendously from the dynamic exciter. The static exciter is a solid state device, physically mounted in its own shack away from the turbine generator, and powered by auxiliary plant power. The dynamic exciter is a mechanical device resembling a large motor, physically mounted on the turbine generator shaft directly behind the generator, and powered only by the high speed rotation of the turbine generator shaft. Whereas before 2004, if the exciter field breaker was left closed, the dynamic exciter would be made ineffective by the slowing turbine generator shaft, since 2004, the static exciter would be able to, and did, maintain and even increase power to compensate for the slowing turbine generator shaft.

A root cause of this event is that the intended crew action was not performed, the Crew 2 CO neglected to perform the simulator based and lesson plan based training requirements to manually trip the exciter field breaker, therefore causing the generator failure event. A contributing cause was the failure of the Shift Supervisor to direct the CO to follow the procedures and training relative to the activities being performed.

A contributing cause of this event is the automatic exciter field breaker trip on generator breaker open and low turbine generator shaft speed omission from the control system upgrade to DCS in 1997, and, additionally, its omission in 2004 when the inherently protected dynamic exciter was replaced by the static exciter.

This was a missed opportunity by:

1. the DCS contractor engineers, PGE corporate and Boardman Plant engineers during the design of the DCS;
2. the DCS contractor engineers, PGE corporate and Boardman Plant engineers during the installation verification and start-up testing actions on the DCS;
3. the static exciter design and installation engineers, PGE corporate and Boardman Plant engineers during the static exciter modification design and installation actions; and
4. the static exciter start-up engineers, PGE corporate and PGE Boardman Plant engineers during logic checks for and during initial static exciter start-up testing.

In the course of the investigation, the Crew 2 CO commented that the procedure neglected to provide direction regarding operation of the exciter field breaker. Plant procedures material to this event include Operating Instructions OI-5-1, Turbine Generator Operation[2], and Operating Test OT-5-1D, Main Turbine Mechanical and Electrical Overspeed Trip Mechanism Tests[3].

OI-5-1, page 16, in section B. Operator Auto Cold Start, 3. Synchronizing and Initial Loading (cont.), Procedural Step 34. States:

"Perform OT-5-1D – Actual Overspeed Trip Testing"

OI-5-1, page 16, in section B. Operator Auto Cold Start, 3. Synchronizing and Initial Loading (cont.), Step 34. Remarks States:

"**CAUTION** Voltage regulator should be "Off" and exciter field breaker open during OT-5-1D."

OI-5-1, page 16, in section B. Operator Auto Cold Start, 3. Synchronizing and Initial Loading (cont.), Procedural Step 35. States:

"Latch the turbine. Voltage regulator should be "Off" and exciter field breaker open during OT-5-1D."

OT-5-1D, page 1, in section A. INITIAL CONDITIONS, REMARKS, states:

"NOTE: Refer to OI-5-1, Page 12, Step 22."

OT-5-1D, page 1, in section A. INITIAL CONDITIONS, PROCEDURAL STEPS, 1., states:

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[2] Operating Instructions OI-5-1, TURBINE GENERATOR OPERATION, January 2004, signed January 17, 2004, Approved by T.D. Meyers
[3] Operating Test OT-5-1D, Main Turbine Mechanical and Electrical Overspeed Trip Mechanism Tests, Revision 4, September 1999, signed October 28, 1999, Approved by Tom Kingston

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"The turbine/generator is off-line and at rated speed (3,600 rpm) after completing the 4-hour heat soak at 10 percent load (50 MW)."

OT-5-1D is the main turbine electrical and mechanical overspeed trip mechanism testing procedure. It is concerned with tripping the steam supply to the turbine when the turbine generator shaft speed exceeds a predetermined set point. This trip cannot be performed with the generator attached to the grid; therefore, step 1 tells the performer to take the generator off-line. No other words in OT-5-1D tell the operator how to perform that task. The aforementioned note in OT-5-1D refers the performer to OI-5-1, the operating procedure that does instruct the performer about the proper steps to take the generator off-line. However, the referred page and step number in the note do not coincide. OI-5-1 page 12 includes steps 16 and 17 as opposed to step 22. Step 16 removes generator breaker from "Pull to Lock", and Step 17 closes the generator breaker. Step 22 of OI-5-1 is located on page 13 and refers to setting the 10 percent load plateau on the generator.

The OT-5-1D note references need to be reviewed and revised. Repeated branching in the operator procedures constitutes a human error trap that should be corrected.

The plant is operated on a day to day basis using OI procedures. Special tests and manipulations refer to the OT procedures for those tests and manipulations. That OT-5-1D did not specify the method and specific steps for the generator trip and exciter trip is immaterial because OT-5-1D involves testing the overspeed of the generator shaft, a condition that could only occur with the generator tripped. OT-5-1D expects that the operator enter the procedure with the generator properly taken off-line.

OI-5-1, on the other hand, is designed and developed to specify exactly how to take the generator off-line in a proper fashion. Steps are included to move the operator to OT-5-1D and returning from OT-5-1D to carry on with placing the turbine and generator on-line. That OT-5-1D referred to the wrong step and page in the note may have confused a lay person, however, one must remember that the procedures were written for control room qualified operators. The operators performing the test were long-term, seasoned control room qualified operators. It would be a normal expectation that the control room operator would be able to understand the OT-5-1D note referred him to the wrong step, steps that he had performed and should have recognized he had performed, and would look further through the procedure to page 16 and steps 34 and 35 in OI-5-1. There he would have been cautioned to open the exciter field breaker during the performance of the turbine overspeed trip test, an action that was not performed.

A <u>root cause</u> of this event is the CO failed to follow plant procedure by not manually opening the exciter field breaker following the generator output breaker trip, thus causing the subsequent generator failure.

At 2207, Crew 2 opened the main generator output breaker. That action stopped power generation from the Boardman Plant generator to the electrical grid.

At 2229, twenty-two minutes after the generator was taken off-line and stopped supplying electric power to the grid, the first overspeed trip occurred. Generator frequency alarms were received immediately following the turbine trip. If the exciter field breaker had been opened, no alarms associated with electric power production would have been expected. The receipt of these alarms should have alerted the operators to the significant abnormal condition.

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At 2230, twenty-three minutes after the generator was taken off-line and ceased supplying electric power to the electrical grid, the "Exciter Min Limiter Active" alarm came in. This is significant in that it is the first exciter-specific alarm, and it is a Priority 2 (a heightened priority and response expectation) exciter problem. This means that the alarm should have been investigated and the exciter should have been the focus of that investigation.

At 2231, twenty-four minutes after the generator was taken off-line and ceased supplying electrical power to the grid, the "Exciter Backup Channel Active" alarm annunciated. Within two minutes, three power generation related alarms annunciated on a shut down generator, with two of those alarms, including a priority 2 alarm, related to the exciter. In actuality, the static exciter was maintaining the generator magnetic field and putting heat into the generator. Only the spinning generator shaft protected the generator from damage due to overheating.

At 2307, one-half hour after the generator was taken off-line, the main turbine was tripped and allowed to begin coasting down to a virtual stopped state so that the former dynamic exciter cover could be removed and the Torque Strain Relay (TSR) units, forgotten to be installed on the exciter shaft stub during the outage, could be installed. TSR units are installed on each end of the turbine generator shaft and monitor the low level harmonics produced by electrical grid perturbations. In the event that the harmonics get too large, the TSR units remove the generator from the grid, thus protecting the turbine generator shaft from damage.

Had the TSR units not been forgotten, the electronic overspeed trip not needed resetting, and the vibration transducers not needed adjustment, the turbine would have been 'caught' and rolled to back to 3600 rpm following the second overspeed trip, instead of being shut down. Replacement of the TSR units required a deviation from that normal start-up. After the overspeed trip, the generator shaft had to be slowed to a complete stop. The shroud covering the exciter collector shaft, called the "doghouse", was to be removed, and the TSR units installed in their mounts inside. Upon installation of the forgotten TSR units, the shroud was to be reinstalled, the turbine latched and spun back to 3600 rpm, and upon reaching proper plant conditions, the generator output breaker closed to place the Boardman Plant back on the electrical grid.

During electric power generation, some of the work in making the electricity is converted into heat. Generator vendors make provisions to remove heat by using hydrogen, a heat transfer gas, as a medium to transfer heat to the stator cooling heat exchanger, and, in the Boardman Plant, ultimately to the cooling pond. The rotor in the generator is equipped with a fan that moves the hydrogen and allows it to contact all of the hot surfaces, pulling away the heat and removing it to the heat exchanger.

When the generator output breaker was opened, the heat from electrical power generation was no longer produced in the generator. The rotating generator shaft should have cooled the heated generator components. However, the exciter field breaker was still closed, supplying high levels of power, and thus heat, to the generator rotor.

At 2332, one hour and twenty five minutes after the generator stopped making electric power, the "High Cooling Gas Differential Temperature" alarm annunciated in the control room. Five minutes later, the "Stator Differential Temperature" alarm annunciated in the control room. One and one half hours after the generator output breaker was tripped open so the generator was not producing electric power, and thus heat, and with its shaft rotating at high speeds while

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undergoing overspeed trip testing, thus forcing hydrogen to transfer heat to the stator cooler and cool the generator components, two alarms signifying abnormal heating in the generator annunciated in the control room within five minutes of each other.

A root cause of this event is that several alarms related to generator and exciter abnormal conditions were not investigated and analyzed by the Crew 2 CO. This failure to respond to indications resulted in extensive damage.

At 2345, the doghouse was removed to facilitate TSR unit installation. The generator field excitation conductors are located inside of the doghouse. When the doghouse was removed, those aforementioned high levels of power for generator field production and their conductors were immediately exposed. Boardman Plant procedures, 29 CFR 1910.269 R Special Industries, Electric Power Generation, Transmission, and Distribution and OAR 437-002-1910.269 R Special Industries, Electric Power Generation, Transmission and Distribution require the development and implementation of a hazardous energy control procedure before the doghouse is removed.

The hazardous energy control procedure is a mapped out set of locks and tags that ensure that every energy source that could cause personal injury to the personnel involved with work is removed from being an energy source. Additionally, planning and pre-job briefings are required for all personnel so that everybody understands the scope of work and all identifiable hazards to performing the work.

The exciter doghouse was removed at 2345, and the TSR units were installed without a hazardous energy control procedure, violating Boardman Plant procedures, 29 CFR 1910.269 R Special Industries, Electric Power Generation, Transmission, and Distribution and OAR 437-002-1910.269 R Special Industries, Electric Power Generation, Transmission and Distribution. When the workers, I&C technicians, opened the exciter doghouse, they witnessed the brushes on the energized exciter field circuit jump and the lights in the turbine building dim as exciter power flowed unprotected nearby. The I&C technicians reported their observations to the Crew 2 Shift Supervisor. The Crew 2 Shift Supervisor did not observe the lights dim, but viewed the exciter components "arcing and jumping." However, he failed to trip the exciter field breaker in order to remove the energized and gyrating conductors from being an immediate personnel and equipment hazard.

Failure to follow the Lock Out/Tag Out, or hazardous energy control procedure, on the TSR relay unit installation job was a missed opportunity to limit generator damage and posed a safety threat.

During the course of the root cause analysis investigation, the Crew 2 CO mentioned that he knew that the exciter field breaker was closed and energizing the generator field. He said that he told the Crew 2 Shift Supervisor. The Crew 2 Shift Supervisor replied that he believed that the exciter field breaker would automatically open and de-energize itself. The Crew 2 Shift Supervisor personally witnessed the jumping of the exciter field circuit components inside of the doghouse and did not trip the exciter field breaker. The energized static exciter remained energized until about 0020 on February 6, 2006, when an exciter firing circuit protective circuit actuation effectively de-energized the exciter field in the generator. At 0734, day shift Crew 4 tripped the exciter field breaker.

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A root cause of this event is that the Crew 2 CO and Crew 2 Shift Supervisor knew that the exciter field breaker was closed and supplying current to the generator field and did not perform actions to remove generator field excitation power by tripping the exciter field breaker.

VI. References:

Al Mathis, Control Operator Boardman Plant
Ralph DeBoer, Assistant Control Operator Boardman Plant
Jason Stillman, Assistant Control Operator Boardman Plant
Lee Archer, Control Operator Boardman Plant
Thomas Meyers, Operations Manager Boardman Plant
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Vinnie, Westinghouse Seimens Exciter Tech Rep
DCS Screen
February 2006 02/20/06 Rev 12 Shift Schedule
Boardman Plant 2006 Maintenance Outage Start-up Schedule, February 2006 – Rev1
Boardman Plant – Control Operator Log, Sunday, February 05, 2006, Shift 0700-1900
Boardman Plant – Shift Supervisor's Log, Sunday, February 05, 2006, Shift: Night (1900-0700)
Boardman Plant – Shift Supervisor's Log, Monday, February 06, 2006, Shift: Day
Boardman Plant – Control Operator Log, February 5, 2006, Shift Night
Boardman Plant – Control Operator Log, Monday, February 06, 2006, Shift Day
Generator Chronological Events
T.D. Meyers to File, John Dawson Generator Rotor Incident 2/6/2006, February 9, 2006
T.D. Meyers to File, Al Mathis 2.6.2006 Generator Rotor Incident, February 9, 2006
John Dawson, Incident Report Generator Arcing February 6, 2006, February 7, 2006
Stone Kay SFSI to Stone Kay SFSI, Boardman, Tuesday February 07, 2006, 10:25 AM
07-Feb-2006 drop 200 Mark-up
Boardman Power Plant Field Current Trace
OI-5-1, Operating Instructions OI-5-1 Turbine Generator Operation, Portland General Electric Company Boardman Plant, January 2004, Rev.2, Approved by T.D. Meyers, 1/7/2004
OT-5-1D, Operating Test OT-5-1D Main Turbine Mechanical and Electrical Overspeed Trip Tests, Portland General Electric Company Boardman Plant, September 1999, Revision 4, Approved by Tom Kingston, 10/28/99
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Logic Diagram Exciter Field Breaker (System MB) J-2001
Power System Stabilizer Tuning and WECC Modeling, Boardman GS, K2004-43, Kestrel Power Engineering
Westinghouse Turbine Generator Owners Manual
Cutler Hammer Exciter Owners Manual
HSR Alarm Message, Start time 05-Feb-06 22:13:00 PST End Time: 06-Feb-06 01:23:57 PST
Boardman Plant 2006 Staff Chart
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PGE Job Description Shift Supervisor, Boardman Operations, RC 042, August 2000
Bulletin No. 98U-196, Assistant Control Operator
Position Description Control Operator, RC 042, July 2001
Portland General Electric Company Boardman Plant Training Procedure TP-1-5 Shift Supervisor Qualification, June 2002, Revision 0, Approved By Thomas D Meyers, Date 6/24/2002
TP-1-3 Study Items-Check Offs, Appendix A, Revision 1
TP-1-3 Control Operator Qualification Appendix C, Revision 1
TP-1-3 Principal Factors Appendix B, Revision 2
Control Room Operator Trainee Evaluation, TP-1-3, Appendix D, Revision 1
DCS Control Logic Printout
Westinghouse Electric Corporation PGE Boardman Motor Control Functional Exciter Field Breaker 41A 152-1A101, Drawing MCL DPU14, SH 37, Rev 4
Schematic Meter & Relay Diagram Main System, Unit 1, Drawing 1-E-200, Sh 1, Rev 18
Boardman Plant Meter & Relay Generator Schematic Diagram, 1-E-200, Sheet 2, Rev 5
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Boardman Plant Scheme Static Exciter 1E04, E18-203 Sh.4, Rev 1
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Boardman Plant Scheme Static Exciter 1E04, E18-203 Sh.5, Rev 1
Boardman Plant Schematic Diagram Gen. Excitation Voltage Regulator 1-E-265 Sh.1 Rev8
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Boardman Plant Analog Diagrams 1-E-265 Sh.4 Rev1
Boardman Plant Analog Diagrams 1-E-265 Sh.3 Rev8
Boardman Plant Schematic Diagram Generator Static Exciter 1-E-265 Sh.5 Rev1
Boardman Plant Schematic Diagram 41A 7.2KV Exciter Field Breaker 1A101 1-E-266 Sh.1 Rev11
Boardman Plant Schematic Diagram Gen, Main & Unit Aux XFMR Protection 1-E-270 Sh.1 Rev8

VII. Attachments:

Attachment 1	Chronology
Attachment 2	Events and Causal Factors Chart

CERTIFICATE OF SERVICE

UE 196

I certify that I have this day served the foregoing document upon all parties of record in this proceeding by delivering a copy in person or by mailing a copy properly addressed with first class postage prepaid, or by electronic mail pursuant to OAR 860-13-0070, to the following parties or attorneys of parties.

Dated at Salem, Oregon, this 5th day of June, 2008.

Kay Barnes

Kay Barnes
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Regulatory Operations
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