Robert J. Budnitz
734 The Alameda, Berkeley California 94707
telephone 510-527-9775
fax 510-527-1203
e-mail: budnitz@pacbell.net

DRAFT FOR REVIEW BY DON LAFRENZ

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TO: Donald Lafrenz, CPUC

FROM: Robert Budnitz

SUBJECT:
An evaluation that explains why the performance of the replacement steam generators at Diablo Canyon Power Plant has been different than the performance of the replacement steam generators at SONGS

SCOPE

In the "Scope of Work" part of the CPUC agreement that engaged my consulting services, the first "Deliverable" is described as follows:

> *Within approximately 90 days of the commencement of the contract (the contract is expected to commence by the middle of September 2013) provide a report to the Energy Division with an analysis focusing on why the steam generators at DCPP and their design has been successful while the SGs design by Mitsubishi for SONGS resulted in excessive tube wear and tube failure.*

In my first meeting with you and your CPUC colleagues on 30 September 2013, you noted that one important part of this evaluation would be to review the findings and conclusions of the Diablo Canyon Independent Safety Committee (DCISC) on this same technical issue.

WHAT I DID

First I reviewed the DCISC's 2012 and 2013 Annual Reports to find what I could on this subject. (Of course, I am one of the 3 members of the DCISC, so this was easy for me to do.) Then, I reviewed the information that I had already learned from my study of several different documents that I had been reviewing anyway, so as to gain a full understanding of the technical issues related to the events at SONGS. These included documents from So. California Edison, from Mitsubishi, and from the US Nuclear Regulatory Commission, along with general information on steam generator performance that I had available to me.

Then I thought about the issue a bit, sat down, and I am writing this report.

MY ANALYSIS

The explanation of why the performance of the RSGs (replacement steam generators) at Diablo Canyon has been different than that of the RSGs at SONGS is on one level rather easy. A major part of the explanation is that the specifications for the DCPP and SONGS designs, while superficially similar, are quite different. The SONGS RSGs are much larger --- the SONGS reactor design uses two SGs per unit, while the DCPP design has four SGs per unit, so the amount of energy, power, water, etc. that the SGs at SONGS need to process and cope with at full power is about twice as large. (This is approximate – the DCPP reactors produce about 6-7% more power than did those at SONGS, a modest difference.)

This size difference by itself places very different constraints on the RSG design in terms of flows, stresses, material properties, and the like. The design solutions always need to embed "margin" in various attributes to assure that performance is adequate, but the way these margins are determined, the places where they are embedded, the amounts of the different margins, and the figures-of-merit used by the different designers are all different, sometimes markedly so. For example, there are margins in the heat-transfers, in the material strengths, in the configuration tolerances and clearances, in the allowances for manufacturing errors, and so on. Taken all together, these margins should produce a final design that will operate without the problems that were experienced at SONGS. And the fact that the SONGS and Diablo Canyon RSGs are so different in size means that these design solutions are surely very different in detail.

Second, the designs were executed and the SGs were built by different manufacturers, Mitsubishi (a Japanese firm) in the case of SONGS, and in the case of DCPP Equipos Nucleares SA (a Spanish firm, but with major parts made by subcontractors in Japan and Sweden.)[*] As is true of many other pairs of similar products made by different manufacturers (think of similar passenger cars by Ford and Toyota, or similar commercial aircraft by Boeing and Airbus, or even similar household refrigerators or furnaces), the design solutions arrived at by the various manufacturers are different enough that they are simply not comparable at the level of detailed engineering. Hence, only a minutely detailed comparison at the level of numerous specific design decisions (involving the numerous "tradeoffs" that are the real nitty-gritty of any complex design problem) could reveal genuine differences that would affect performance.

Third, and most importantly, it is clear that somewhere along the line as the SONGS RSGs went from conceptual design to detailed design to fabrication to testing to installation to operation, one or more errors was made. That this is so almost a tautology --- Mitsubishi itself has produced RSGs at other nuclear plants around the world that have performed satisfactorily, as have the RSGs made by several other SG manufacturers. On the part of everyone involved, there was every expectation that this successful

[*] The major forgings for DCPP's RSGs were made by Japan Steel Works and the tubing was made by Sandvick, a Swedish firm, all under subcontract to ENSA.

performance record would be true at SONGS also. It wasn't, and that implies one or more errors somewhere --- I am not sure where, but somewhere.

My insight from observing that different design solutions were found for a "similar design problem" for SONGS vs. DCPP is that, because of the differences (size, for one, but other differences too), the opportunity for a similar error was very small – not zero, but very small.

Most importantly, the RSGs at Diablo Canyon have performed very well so far, since 2008 (Unit 2) and 2009 (Unit 1), meaning into what is now Unit 2's third refueling cycle and Unit 2's fourth cycle. Based on this experience, it is clear that no similar error(s) occurred at DCPP. Thus my answer to the question in the "Scope of Work" ("*why the steam generators at DCPP and their design has been successful while the SGs design by Mitsubishi for SONGS resulted in excessive tube wear and tube failure")* is that at DCPP no comparable errors were committed.

That, in a nutshell, is my evaluation of the difference. If it sounds obvious – well, it is.

This was also the evaluation of the DCISC when the committee asked (and tried to answer) the same question. The DCISC's remit is evaluating the operational safety at Diablo Canyon, and to discharge that remit the DCISC reviewed the performance of the RSGs at DCPP after the adverse news from SONGS made it pressing to do so. Based on that review, the DCISC members convinced themselves that problems similar to those at SONGS had not occurred at DCPP. The DCISC then wrote that down and moved on – with the caveat that the DCISC has committed to reviewing the performance of the Diablo Canyon RSGs on an ongoing basis, after each outage for example, or whenever other information may arise. And to date, the information supports a continuing conclusion at DCPP of "so far so good."

The DCISC documented its conclusion on this technical topic in its May 2012 Fact Finding report, which conclusion was repeated verbatim in its 2011-2012 Annual Report (released in autumn 2012), to wit:

> *Because of the San Onofre Generating Station (SONGS) Steam Generator (SG) tube failures of relatively new SGs, the DCISC reviewed the health of DCPP's relatively new SGs. DCPP's SG tubes had shown excellent inspection and test results in Outages 2R15 and 1R16 and are considered to be in excellent health. DCPP's plant and SGs were designed and fabricated by a different manufacturer than SONGS. Although in excellent health, the DCISC will monitor SG inspection results during future outages.*

This simple conclusion is all that can be found in the DCISC's 2011-2012 annual report on this subject. Nothing that has arisen from inspections or other performance data at DCPP in the intervening year-plus has provided any information that would challenge this conclusion, and the subject is not discussed explicitly in the DCISC Annual Report for 2012-2013.

IS MORE DESIRED?

I have tried to provide as straightforward an answer as I can to the question asked ("*why the steam generators at DCPP and their design has been successful while the SGs design by Mitsubishi for SONGS resulted in excessive tube wear and tube failure.")*

If more is desired, then I can undertake it. But that would be addressing a different question. Such a question might be, for example,"*What error(s) led to the tube failure(s)?*" or "*At what stage were those errors made?*" or "*Who made those errors?*" or "*What might have been done, and by whom, and at what stage, to have averted those errors?*" or "*What arrangements in place elsewhere, technical or administrative or both, that were successful in averting these errors somehow didn't work adequately for the SONGS RSGs?"* Each of these is a much bigger question, one that I am developing insights into but on which my opinion(s) will only crystallize later as I dig into more information.