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SUBJECT: Forwards response to NRC questions on human factor analysis re licensee PRA.

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James D. Shiffer
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December 8, 1989

PG&E Letter No. DCL-89-313

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

Re: Docket No. 50-275, OL-DPR-80
Docket No. 50-323, OL-DPR-82
Diablo Canyon Units 1 and 2
Long Term Seismic Program - Probabilistic Risk Analysis

Gentlemen:

As discussed in a meeting on November 15, 1989, between PG&E and the NRC Staff, enclosed is additional documentation on PG&E's probabilistic risk analysis (PRA). The enclosure provides clarifying information on five items related to human actions analysis that were identified in the NRC's October 4, 1989 letter.

Kindly acknowledge receipt of this material on the enclosed copy of this letter and return it in the enclosed addressed envelope.

Sincerely,

J. D. Shiffer

cc: N. Chokshi
A. P. Hodgdon
J. B. Martin
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ENCLOSURE

PG&E'S RESPONSE TO NRC QUESTIONS
ON HUMAN FACTORS ANALYSIS

Item 1: It is stated in the DCPRA that SLIM-MAUD type algorithm was used to quantify human errors but neither the exact nature of the algorithm (how it differs from SLIM-MAUD and why) nor its conceptual foundation is described in the DCPRA report. However, our review of Appendix G does not clarify the derivation of SLIM-MAUD used in the analysis or its conceptual foundation. Additionally, it does not clarify how data from training simulators, and data collected directly from operator personnel (including their sampling) were used to index PSF values which supported human error quantification.

Response:

The Diablo Canyon Probabilistic Risk Analysis (DCPRA) used a success likelihood method to analyze human actions. This method was similar to the SLIM (NUREG/CR-2986 (83) and 3518 (84)) method in a number of aspects, but, as a whole, was a unique method. The similarities include the use of performance shaping factors (PSFs) (e.g., information, procedures, time, and training), assessing the relative importance of the PSF for the task, assigning a value as to how good the PSF is in the task under consideration, and multiplying the importance by the values and summing the products to get a success likelihood index for the human action.

The DCPRA human actions analysis method was unique in its development, form of PSF equations, and application. The human action analysis development began with a two-day meeting of approximately six Pickard, Lowe, and Garrick (PL&G) and PG&E human factors analysts. The first task in the meeting was the selection of the PSFs. Emphasis was placed on choosing independent PSFs, PSFs that acted in only one "direction," (i.e., stress can both improve and impede operator performance depending on the amount), and PSFs that are the constituents of stress. After the PSFs were selected, they were combined in an equation with appropriate coefficients, or weightings. Emphasis was placed on the equation form for direct and inverse acting PSFs, and on the proper balance among the major PSF categories: time, training and experience, procedures, indications, personnel, and consequences. Separate equations were developed for the three parts of each human action (identification, diagnosis, and response), and for three different types of human action (skill, rule and knowledge). (See PG&E letter DCL-89-152, dated June 2, 1989, Appendix G, Section 2, for details.) After the PSFs and equations were defined, they were reviewed and refined in a process that continued for approximately six months.

The PL&G and PG&E human action analysts observed a number of simulator sessions (Section G.2.5 of DCL-89-152). These sessions were helpful in understanding general operator response and other qualitative information which was useful in the development and refinement of the human action model. No data was taken during these simulator sessions for use in PSF rating or calibration of the model.

The application of the human action model did not occur until after model development and refinement, which included several test analyses, were complete. The application was a two step process. The first step was the

development of the survey forms for the human actions chosen for analysis. The survey form describes the scenario and assumptions for plant conditions which form the bases for the human action. It defines all other parameters important to the human action (see Appendix G.7 of DCL-89-152). In this step a survey form was developed by PL&G and PG&E analysts for each human action (survey form Sections A, B and C). After the survey forms were completed, they were reviewed by plant operations personnel and others. Refinements in the survey forms content and resolution of specific comments were made. After it was concluded that the survey forms properly defined the human action (DCL-89-152, Appendix G, Section 9), the second step, the assignment of PSF values, or rating, was performed. In this step, generally, two groups of three operators rated the 21 PSFs for each human action. Each group reviewed and discussed the human action as defined by the survey form to reach a consensus on its interpretation. Then each operator independently rated the human action using a clearly defined scale (DCL-89-152, Table G.2-1) and provided information stating their understanding of the action (survey form Sections D and E). The operator ratings (DCL-89-152, Table G.3-1) are the only ratings used to develop success likelihood values.

A simple computer program was developed to calculate the success likelihood index from the PSF ratings using the equations. Since these equations are unique and had already been defined, the MAUD computer program was not used.

Item 2: More discussions are needed to understand how the Human Cognitive Reliability (HCR) model was used to analyze recovery actions.

Response:

The Human Cognitive Reliability (HCR) model was the source for the six success likelihood index curve calibration points (DCL-89-152, Section G.2.3.3 and Figure G.2-1). The human actions failure rates were determined with the HCR model as part of the TMI PRA. The failure rate and the success likelihood index value resulting from applying the DCPRA model plus the origin provided the two points required to define the curves.

Item 3: Discussions are needed as to whether human error was treated or not as a distal contributor (e.g., test and maintenance) to component failures and/or human errors probabilities input to the main accident sequences, and whether human error was treated or not as an immediate precursor (initiator) of the sequences themselves.

Response:

The following response is presented in three parts: human errors as contributors to component failures, human errors in the main accident sequences, and human errors as initiators.

Human Errors as Contributors to Component Failures.

Those errors which contribute to component failures or system unavailability were modeled in several ways; errors associated with maintenance activities, which subsequently result in the component being unavailable, are included in the component failure data. For example, if a maintenance error resulted in the failure of a standby pump to start when demanded, then this failure event would be included in the data which is used to derive the failure rate for pump start on demand. No breakdown is presented in the Human Action Analysis or the Data Analysis reports in regard to the relative contribution of human errors to component failures.

Human errors associated with incorrect system alignment after performance of surveillance tests are explicitly modeled (i.e., the probability of failure to return the system to its correct alignment, and the period for which the system would remain in the incorrect alignment, are modeled explicitly as contributors to system unavailability). Due to the limited amount of plant specific data for these types of events, the human error rates for these actions were based on generic data. The ultimate source of this data was NUREG/CR-1278, October 1980; Handbook of Human Reliability Analysis with Emphasis on Nuclear Power Plant Applications.

Human Errors in the Main Accident Sequences

Human errors were incorporated in the main accident sequences through the event tree top events. In some cases, the top events represented human actions only; in other cases, the top events represented both random hardware failures and human errors.

Human Errors as Initiators

The DCPRA did not explicitly model any human errors as initiating events. Plant specific initiating event data was collected and sorted into initiating event group types such as turbine trip, reactor trip, loss of condenser vacuum, etc. If a human error was the cause of a reactor trip, then that event would have been included with the data used to calculate the reactor trip initiating event frequency; similarly, if the human error was the cause of the loss of condenser vacuum, then that event would have contributed to the loss of condenser vacuum initiating event. No breakdown is presented in the Human Action Analysis or the Data Analysis reports in regard to the relative contribution of human errors to initiating events.

<u>Item 4</u>: Discussions as to whether non-equipment centered PSFs (e.g., supervision, communications, coordination, other group processes) were considered or not in the HRA portion of the PRA.

<u>Response</u>:

Several non-equipment centered PSFs were evaluated:

- Supervision was considered in personnel availability in the control room (V15), outside the control room initially (V16), and outside the control room later (V17).

- Communication was considered in defining human actions as either skill, rule, or knowledge based; in the number of extra unnecessary people (V30); and in operator confusion preceding successful tasks (V7), preceding and concurrent unrelated tasks (V21), and preceding unsuccessful tasks (V22).

- Coordination was considered in the training and experience with indications (V8), diagnosis (V9), performing action (V10); and in the quality of procedures for rule based actions (V11), and not scenario specific (V12).

The NRC Staff is correct in noting that certain group process PSFs, i.e., supervision, communications, coordination, and other group processes, were not explicitly evaluated. However, it is important to understand that the operators who rated the PSFs considered these factors as part of their working and training environment. Therefore, such factors are implicitly included in the PSF rating.

<u>Item 5</u>: The performance shaping factor survey forms (Section G.9 of the PRA) imply that if all the steps of an action are memorized that the action is skill-based. This does not seem in agreement with the basic tenets of the Human Cognitive Reliability (HCR) model. In this model, skill-based behavior is defined as <u>well-practiced</u> behavior. If an action is practiced at most once a year, then, even if the rules are memorized, it is not skill-based behavior, but rather rule-based behavior.

If actions which are not routine actions, such as those performed in response to a fire, were never considered skill-based, but rather were considered rule-based (if procedures were available), what would be the approximate impact on the core damage frequency?

<u>Response</u>:

Although the performance shaping factor survey form indicates that an action is skill-based if all the steps of the procedure have been memorized, consideration was also given to the procedural direction available to the operator, and the operator's training and experience in that action. The Cognitive Process Matrix (DCL-89-152, Figure G.2-4), was used as guidance in determining whether an action was rule-based, skill-based, or knowledge-based. As can be seen from this matrix, actions are only considered to be skill-based if good procedural direction exists and the operators have trained on this action at least every training cycle. It may not have been clear in the Human Action Analysis report that this matrix was used to provide guidance in completing the PSF survey form.

In reviewing Table G.3-1 of DCL-89-152, it can be seen that except for one action, all of the fire related human actions were considered rule based (i.e., at least five out of the six operators classified the action as rule-based). The exception is action ZHEF51; for this action, three out of the six operators believed the action was skill based. The curves used to develop the operator error rates from success likelihood parameters are shown in Figure G.2-1. If the survey results had identified this action as all rule based rather than half rule based and half skilled based, then the error rate for this action would change, on a mean value basis, from 1.35E-2 (i.e., from Table G.3-2) to 2.36E-2, which is an increase of approximately 75 percent.

Action ZHEF51 is only used in the quantification of one fire initiating event originating in the cable spreading room. The core melt frequency from fires, without considering any recovery, is 5.49E-4 per year. With recovery, the core melt frequency from such fires would only increase from 7.42E-6 to 1.30E-5 per year, by assuming that the action is completely rule-based. This would only be a 3% increase relative to the total core damage frequency.