DESCRIPTION

OF THE

SYSTEMS INTERACTION PROGRAM

FOR

SEISMICALLY-INDUCED EVENTS

DIABLO CANYON UNITS 1 AND 2

May 7, 1980

Pacific Gas and Electric Company

SYSTEMS INTERACTION PROGRAM

FOR

SEISMICALLY INDUCED EVENTS

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SYSTEMS INTERACTION PROGRAM

I. OBJECTIVE

The objective of this program is to identify and eliminate any potential undesirable, seismically-induced interactions between non safety-related plant features and those structures, systems, and components important to safety.

II. METHODOLOGY

The methodology is developed from the sequential set of tasks, or task flow diagram, shown in Figure 1. All activities will be monitored by an Independent Review Board.

A. Initial Office Activities

The First Task is the identification of all safety-related functions. Next, all essential safety-related systems that are required for the performance of these functions will be identified by PG&E systems engineers in cooperation with systems engineers from the Westinghouse NSSS supplier. All individual components that are essential parts of the required systems will be listed. Most safety-related functions can be performed by more than one system and this redundancy will be maintained, even though it was originally incorporated as protection against such events as unforeseen system interactions. All functions, systems, and components will be tabulated in matrix form, together with associated information such as operability requirements.

The Second Task is the preparation of a list of required equipment according to location in the existing plant fire zones, which provide convenient spatial subdivisions. These spatial subdivisions will also provide a means for addressing intercompartmental interactions during the plant walkdowns.

The Third Task is the preparation of detailed working criteria for:

1. Postulation of failures for non-seismically qualified equipment.

2. Postulation of effects due to interactions with essential equipment as a result of these failures.

3. Technical evaluation of potential interactions.

4. Resolution of such interactions.

Some of these working criteria will be cast in a form suitable for use during the field walkdowns; others will be directed toward office evaluation and resolution.

Finally, a documentation data base, suitable for providing quality control for the entire systems interaction program, will be designed to ensure that all potential interactions are documented and resolved in a traceable and retrievable manner.

B. Field Walkdown Activities

1. Confirming Walkdown

After the essential components have been identified and located during the office evaluation phase, an inspection will be conducted of each fire area to ensure that the data base to be utilized during the walkdown is accurate and complete.

2. Interaction Walkdown

A second walkdown will be performed by an interdisciplinary team of experienced engineers. During the inspection, all possible interaction failure types will be postulated for non-seismically qualified equipment that might affect the system to be protected. Consideration will be given to local equipment arrangements and geometry and the possible results of these failures. The interaction team, after identifying all possible interactions between nonqualified equipment and safety equipment, will utilize the working criteria to determine if these interactions can take place. Once the field system evaluation has been completed the following information will be added to the computer data forms:

a. Location of the potential interaction.

b. Components of system involved.

c. Working criteria section used for the evaluation.

d. Recommendation of the interaction team. This may take the form of one of the following:

1) Recommendation that a physical modification be designed and installed.

2) Finding that interaction does not occur and that it impairs no safety function.

3) Recommendation for further evaluation.

The interaction team will consider relevant nonessential failures such as loss of electricity, pressure, etc., which may have an effect on the operation of safety-related equipment.

When the Interaction Team enters a given room, color coded system drawings will be used as a map or chart to follow all systems that require protection. As each item and its environment are inspected, it will be checked off the master

list or matrix. Before leaving the system and going to the next, nonqualified equipment in adjacent rooms will be inspected to determine possible inter-compartmental interactions.

During the plant walkdown, each item of equipment on the list to be protected will be inspected by the Interaction Team. Each unit of non-seismically qualified equipment in the vicinity of the item will be considered to fail by any or all of the specific mechanisms listed in the working criteria. When failure has been postulated, it will be possible during the inspection to determine interactions with the safety equipment. All such interactions will be listed and evaluated using the working criteria. Interactions of the following types will be considered as appropriate:

- Mechanical
  - impact from vibrating bodies
  - impact from falling bodies
  - pipe whip
  - missiles
- Electrical
  - unwanted open circuit (loss of power or control)
  - unwanted closed circuit
  - unwanted energization
- Pneumatic
  - loss of pressure (loss of control)
  - unwanted pressurization
  - jet impingement
  - hostile gas
- Hydraulic
  - loss of pressure
    - loss of control
    - loss of lubrication

- unwanted pressurization
- jet impingement
- flooding
- hostile fluids

• Environmental

- elevated temperatures
- steam
- radiation

Secondary or chain-type interactions will be evaluated in which the equipment that fails first interacts with another which, in turn, interacts with shutdown equipment. In view of the extensive theoretical possibilities, an attempt to list all such interactions would be impractical or misleading. However, because of the carefully structured nature of the systems interaction review program, and because of the team inspection approach, it is expected that all harmful secondary or chain interactions will be observed during the program. These will be tabulated with the primary interactions to form a complete list.

Non-seismically qualified equipment will be assumed either not to operate or to operate incorrectly, whichever produces more serious consequences. Mechanical or structural failures will be postulated according to the working criteria. The operability interactions will be established by the systems engineers through a study of systems diagrams. The structural, mechanical, and environmental interactions will be studied by means of the interdisciplinary team of engineers performing on-site inspections.

3. Inter-Compartmental Walkdown

The third walkdown by the interdisciplinary team will consider the effects of inter-compartmental interactions. All possible inter-compartmental interactions will be identified and relevant data such as color coded system drawings, geographic and relevant numerical data will be entered on the computer data forms. The walkdown team will physically inspect all connected compartments that may have interaction effects. Items such as flooding, electrical, pressure, and dynamic effects will be considered. Further interaction effects that may be determined from evaluation of the data base information may require a second inter-compartmental walkdown.

C. Walkdown Audit

After field walkdown activities associated with a group of compartments have been completed, another team will perform a sampling walkdown of representative compartments and their related inter-compartmental interactions. The purpose of this walkdown is to verify, on a sampling basis, that the original walkdowns were complete and accurate. If completeness or accuracy are found to be deficient, the deficiencies will be corrected and the sampling rate will be increased for subsequent groups of compartments.

D. Technical Evaluation

As the data from the field walkdowns are obtained, office-based technical evaluations will be performed on unacceptable conditions noted in the field. Analyses, testing, and historical experience will be used to determine if the field-noted unacceptable condition is valid based on previously determined working criteria. If these office techniques demonstrate adequacy, no further activity (except documentation) will be required; otherwise, the unacceptable condition will be corrected by design modifications. If the unacceptable condition is not resolved by technical evaluation techniques, the resolution will be accomplished by design modification.

E. Modifications

As soon as an unacceptable condition is noted in the field and validated through technical evaluation, or it is determined that technical evaluation will not resolve the problem, engineering modifications will be accomplished. Depending on the type of modification required and the provisions of applicable QA requirements, the design will be accomplished either in the field or in the office. Analyses or tests used as the design basis will be as described in Paragraph IV.B.2. All design, analyses, and construction work will comply with project quality assurance and quality control requirements.

After required modifications have been completed, the systems modified will be checked in the field to assure that the modifications themselves have not resulted in unacceptable interaction conditions.

F. Independent Audit

A review team independent of PG&E will conduct a walkdown sample of systems including modified systems.

III. GENERAL CRITERIA

The general criteria provided below set forth rules for the conduct of the program:

- The original safety criteria applicable to the plant will not be compromised due to failure of non-seismically qualified equipment.
- Postulated failures of non-seismically qualified equipment and the consequences thereof will be based upon the 7.5 Magnitude Hosgri earthquake and the spectrum of service loads.
- At the time the earthquake is assumed to occur, the plant will be considered to be in one of three states: operating normally, involved in a normal operating transient, or in a state of hot shutdown.
- There will be no seismically-induced failure of seismically qualified equipment and structures.
- Random single functional failures of active safety-related components will be considered concurrently with seismic failures of non-essential equipment.
- Credible multiple seismic failures will be postulated for equipment and structures that have not been seismically qualified.
- Interactions will be considered when they result from physical failure and/or malfunction of nearby and remote equipment.
- Full loss, partial loss, and no loss of offsite power will be considered.
- Tsunami will be considered concurrently with the earthquake.
- The fire protection system has been separately qualified and it is concluded that it will protect the plant from design basis fires that results from the earthquake. Additional interactions due to fire are not considered.
- Anticipated transients without scram will not be considered concurrently with the 7.5 Magnitude Hosgri earthquake. The seismic trip will trip the reactor at acceleration levels well below those associated with the 7.5 Magnitude Hosgri earthquake.
- Effects of human error, such as adverse operator response during a major earthquake, are not considered.

IV. WORKING CRITERIA

The working criteria will be classififed into categories based upon the conceptual steps involved before, during, and following the field walkdown. First, detailed quantitative criteria will be developed to guide both office and field personnel in the postulation of failures of non-seismically qualified equipment. Second, following failure postulation, criteria for determining the effects of these failures or interactions on the essential safety equipment will be developed. Third, if the prevention of non-seismically qualified equipment failure is inappropriate, criteria will be developed to evaluate the consequences of the interaction on the essential safety equipment. Such consequences represent additional stress and deformation, or operability constraints against proper function, for the essential safety equipment. Finally, criteria will be required to evaluate the consequences of any resolutions or modifications upon plant safety.

In order to develop these criteria, an overall rationale is offered. Then, the rules that govern these detailed criteria are shown in two categories--generic and discipline specific.

A. Rationale

The General Criteria sets forth guidance for bounding the program. The working criteria documents the detailed methodology to which the adequacy of each structure, system, and component is evaluated. The basic philosophy of working criteria development is to utilize generic data, analyses, and tests all coupled with historical observations to establish a definitive set of guidelines to be used as discipline-specific guidance for the field walkdowns. In addition, should systems fail the walkdown criteria, additional working criteria would set forth guidelines for more detailed analyses, acceptance criteria, and criteria for modification.

These guidelines are based on three major considerations. The first is the seismic resistance built into the nonsafety equipment as a result of applicable codes, standards, and industry practice. Second, certain categories of equipment benefit from extensive tests that have been conducted on similar equipment. Finally, the types and categories of failures experienced by power plant equipment in past earthquakes have been incorporated into the guidelines.

There is substantial seismic resistance or capability built into the nonsafety equipment even though it has not been specifically seismically qualified for the present application. In many cases, equipment meets or exceeds the seismic requirements.

A broadly based series of tests has been conducted on cable tray systems, including supports and raceways. These tests show that cable tray systems of all types have great seismic resistance. It was possible even under repeated high level testing to obtain failures in only the most flexibly supported arrangements. Cable tray systems were also found to be much more heavily damped than originally suspected.

The third concept employed in establishing seismic failure modes is the historical record. Since the nonqualified equipment is designed, manufactured, or constructed to essentially the same standards as fossil fueled plants (and, in many cases, the same standards as safety-related nuclear components) it is logical to use the categories of failures actually experienced as a guide. A study of the behavior of piping and mechanical equipment in past earthquakes has been completed. This review included two power plants that experienced ground accelerations of about 60% of gravity, which is approximately the level anticipated at Diablo Canyon if the Hosgri earthquake were to occur. Although the same specific failures are not expected, it is reasonable to base the interaction program on the same categories or classes of failures actually observed.

The specific kinds of failure modes to be evaluated are based upon the above concepts. Postulation and evaluation of these categories of failures ensure the program objectives will be met consistent with the general program criteria.

B. Generic Criteria

1. Load Combinations

All components will be evaluated for the combined effects of seismic loads, normal operating loads, dead loads, and live loads.

2. Analysis Techniques

A stepped approach to levels of analysis will be used, as required, for the generic analyses and for those analyses required due to component failure. These analysis tools are:

- simple classical engineering mechanics
- linear elastic finite element analysis
- pseudo-inelastic finite element analysis
- inelastic finite element analysis

For all the techniques listed, elastic response analysis or direct integration will be used to perform the dynamic analysis.

3. Acceptance Criteria

The results of the analyses will be resolved by one of the following three criteria:

stress - as specified in ASME Section III, Appendix F Faulted Condition Stress Limits

strain - 25% of the minimum specified uniform elogation of the material

ductility factor - for steel components will be less than or equal to 5

4. Testing

Existing test data may be used to develop walkdown criteria. Care will be taken to insure that such data is applicable for this program. Additionally, testing may be used to qualify components which fail other walkdown or analysis criteria. Such testing should satisfy the qualification by test criteria set forth in Paragraph F-1321.1 of Section III of the ASME Boiler and Pressure Vessel Code.

5. Historical Observations

Where existing historical data clearly records acceptable component and equipment performance, detailed analyses and tests will not be performed. Such historical data may be supplemented by generic analyses and tests to develop the walkdown guidelines and criteria.

C. Discipline Specific Criteria

Utilizing the generic criteria, specfic acceptance criteria will be developed for each discipline reviewed as part of this program i.e., piping, HVAC, cable trays, mechanical equipment, structures, etc.

V. DOCUMENTATION

PGandE will document the following items:

A. An onsite working document identifying:

1. Identification of all systems and components required for the performance of safety-related shutdown functions.

2. A listing of essential systems by location within the plant, including methods of identification of the systems.

3. Bases for modification of the walkdown criteria when applicable.

B. A working criteria document defining the bases for accepting or rejecting loads, deflections, support systems, mounting, hold down devices, etc., including permissible and non-permissible interactions between essential or non-essential systems.

C. An on-site examination status report containing all information from the walkdown examinations of equipment. This document will identify interactions among systems and pinpoint systems where analysis and/or modifications may be required.

D. An evaluation document located on the site containing an assessment of the interactions and recommending appropriate action.

E. A modifications document covering any changes made, including all relevant quality assurance documentation.

F. A technical audit document where the audit is conducted by personnel independent of PG&E and covering:

1. A random sample of the systems examined to establish adequacy of the initial examination;

2. A random simple of all modified systems to establish that the modifications were acceptable and that such modifications did not introduce further interactions;

G. A final report to the covering salient features of Paragraphs (A) through (F) above. This document will be submitted prior to full power operation.

SEISMIC SYSTEMS

INTERACTION PROGRAM DESCRIPTION

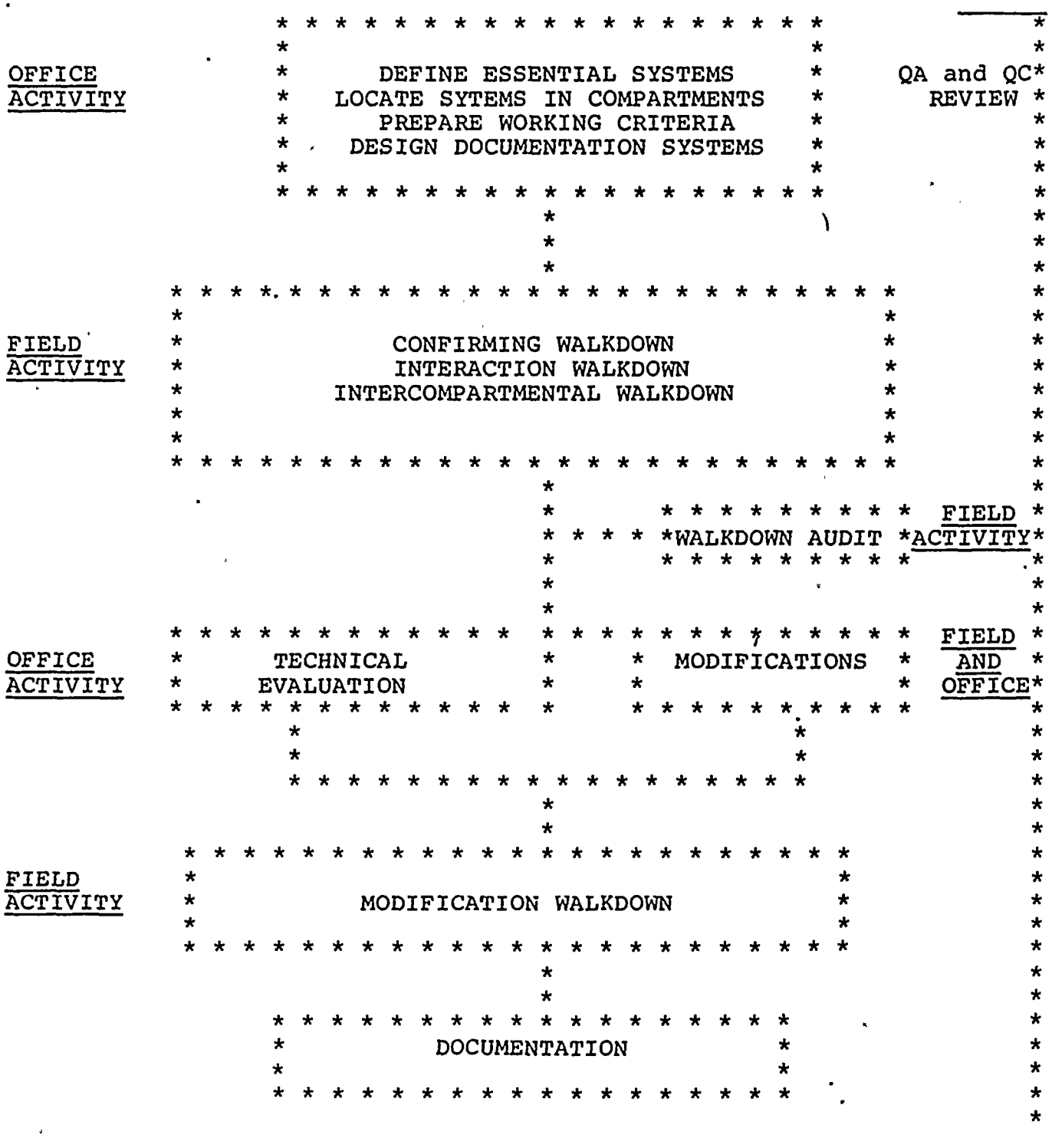

FIGURE I

SEQUENTIAL TASK FLOW DIAGRAM