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Safety standards for construction and operating of Liquefied Natural Gas Terminals established in Western LNG Terminal Associates application.

Decision No. 90372, Case No. OII1; 57626; 57792; 10342

California Public Utilities Commission

*1979 Cal. PUC LEXIS 556; 1 CPUC2d 587*

06/05/79

(For appearances see Decision No. 89177.)

Additional Appearances
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Beardsley, Hufstedler & Kemble, by Dennis M. Perluss, for Kelco Company and John Grattan, Attorney at Law, L. Thomas Tobin, George E. Brogan, and Irwin Karp, for California Coastal Commission, interested parties.
Han L. Ong, for the Commission staff.

**PANEL: [*1]** Sturgeon, Vernon L; Gravelle, Richard D; Dedrick, Claire T; Grimes, Leonard M

**OPINIONBY:** Bryson, John E

**OPINION:** THIRD INTERIM OPINION AND ORDER

I. INTRODUCTION

A. LNG Terminal Act of 1977

On September 16, 1977, Governor Edmund G. Brown, Jr. signed the Liquefied Natural Gas Terminal Act of 1977 (the Act) n1 into law. That legislation grants to this Commission the exclusive power to issue a permit for the construction and operation of a liquefied natural gas (LNG) terminal. In addition, the Act requires the Commission to adopt regulations governing the safety and construction of the terminal and to establish a construction monitoring system. In the latter regard, Section 5637 of the Act provides that

"The Commission shall adopt regulations governing the safety and construction of the terminal . . **[*2]** . and that

"The Commission shall establish a monitoring system to ensure that any terminal authorized pursuant to this chapter is constructed and operated in compliance with all applicable regulations adopted and terms and conditions established pursuant to this Chapter."

n1 *Public Utilities Code Section 5550*, et seq., Chapter 855 (1977), 1977-1978 Regular Session of the California Legislature (SB 1081).

B. Procedural Summary

On October 14, 1977, Western LNG Terminal Associates (Western Terminal) filed Application No. 57626 for a permit to construct and operate an LNG terminal pursuant to the provisions of the Act.

To implement the legislative mandate of Section 5637 of the Act, the Commission on October 18, 1977 instituted OII No. 1, an "Investigation on the Commission's own motion into the matter of the adoption of regulations governing

the safety and construction of a liquefied natural gas terminal in the State of California." Southern California Gas Company (SoCal), Pacific Gas and Electric Company (PG&E), San Diego Gas & Electric Company (SDG&E), and Western Terminal were named as respondents. As a part of the investigation, the staff was directed by the Commission **[*3]** to prepare proposed safety regulations, as well as proposed safety and construction monitoring and environmental monitoring programs.

Section 5630 of the Act required the Commission to issue a decision on the permit application by July 31, 1978. n2 However, the Act did not require the Commission to discharge its mandate to adopt regulations and establish monitoring programs by that date. Because of the time constraint, hearings held in OII No. 1 in 1978 prior to July 31 (Phase I of these proceedings) concentrated on the safety issues relevant to the permit application. With minor exceptions, the Phase I hearings were not directly related to the consideration of the proposed safety regulations or monitoring programs.

n2 On that date the Commission issued its Decision No. 89177 granting a conditioned permit to Western Terminal.

Prior to the commencement of hearings on the proposed regulations and monitoring programs (Phase II), the Commission staff, pursuant to OII No. 1, distributed an initial draft of its proposed regulations to respondents and other interested parties for comment. The participating parties provided staff with extensive comments and suggestions.

On July 7, **[*4]** 1978, the staff filed its proposed regulations (Exhibit No. 0-140, Proposed Revisions of Part I and Part II and Proposed Part III - LNG Facilities Safety Standards of General Order No. 112-C) and certain related exhibits in OII No. 1.

On August 1, 1978, hearings commenced in Phase II of the proceedings to consider the staff's proposed regulations and proposed monitoring plans. In the Phase II hearings evidence was received from staff, respondents, and other parties during the course of 36 days of hearing held before Administrative Law Judge James F. Haley. The matter, insofar as it relates to the proposed safety regulations and monitoring programs was taken under submission on December 15, 1978, subject to the filing of concurrent briefs by February 1, 1979, and reply briefs by February 13, 1979.

Relatively few parties elected to participate in the hearings on the proposed safety standards and monitoring programs. Other than the staff and respondents the only other parties actively participating in the hearings on Phase II were the California Coastal Commission (CCC) and the California Division of Mines and Geology (DMG). Nevertheless, the Commission has before it in this phase **[*5]** of the proceedings a comprehensive and copious record consisting of 52 exhibits and the testimony of many expert witnesses, who were, in most instances, exceptionally well qualified in their areas of concern. By far the greater part of this record treats issues relating to the proposed safety standards, with the lesser part being concerned with the proposed monitoring programs, which engendered considerably less controversy during the hearings.

C. Purpose and Scope of the Safety Standards

The Commission intends that the safety standards established in these proceedings will satisfy the requirements and meet the objectives of *Public Utilities Code Sections 768* and 5632 and General Order No. 112-C, Section 102.2. n3 The Commission's purpose in establishing these safety standards is to provide a high level of safety at LNG facilities by giving consideration both to the special requirements imposed by the low temperature of LNG and to the methods of controlling the potential causes and consequences of accidental release of LNG as a liquid or gas. The safety standards adopted herein will govern not only the LNG facility proposed at Point Conception, but they will apply to all **[*6]** future LNG facilities in California.

n3 *Public Utilities Code Section 768* states:

"The Commission may, after a hearing, by general or special orders, rules, or otherwise, require every public utility to construct, maintain, and operate its line, plant, system, equipment, apparatus, tracks, and premises in such a manner as to promote and safeguard the health and safety of its employees, passengers, customers, and the public . . ."

Public Utilities Code Section 5632 states:

"The Commission shall not issue a permit for construction and operation at any site unless it finds to do so is consistent with public health, safety and welfare and may impose such conditions on the issuance of a permit as may be necessary and appropriate to ensure the public health, safety and welfare."

General Order No. 112-C, Part I, Section 102.2 states:

"These rules are concerned with safety of the general public and the employees to the extent they are affected by basic design, quality of materials and workmanship . . ."

Decision No. 89177, which granted the conditioned permit, specified certain design criteria for the LNG terminal at Point Conception. The conduct of the Phase II hearings, in developing **[*7]** an adequate record for the Commission to promulgate its LNG safety standards, has in a number of instances produced evidence which causes us to conclude that some of these design criteria require interpretation. While it might be a technically correct approach to consider this evidence as bearing only upon the safety standards and irrelevant to and not affecting the design of the Point Conception terminal, such an approach would not be constructive. n4 Therefore, we will in this opinion and order interpret certain design requirements for the Point Conception facility to clarify our intent in Decision No. 89177.

n4 At the hearings of August 3 and November 1, 1978, staff counsel moved to strike Western Terminal's Exhibits 0-117 through 0-128 and parts of Exhibit 0-152. In accordance with our holding above, we find these exhibits to be relevant and material. The two motions to strike are hereby denied.

## II. THE PARTIES AND THEIR POSITIONS

### A. Commission Staff's Position

With the stated objectives of reducing the probability of occurrence of failures within the LNG terminal and reducing the expected consequences of such failures to a level that will promote the health and **[*8]** safety of the public and the terminal's employees; the staff has proposed regulations based upon a "five-level approach to the solution of safety problems."

The "first level" involves the selection of an exclusion criterion based upon the probability of occurrence of specific hazards at the site. The staff states that this level of risk was selected to assure that no hazardous external events (such as earthquake, wind, flood, or aircraft impact) would have a significant probability of leading to an unsafe condition at or near the LNG site. As the exclusion criterion, the staff selected a risk level of 10<-6> per year, or the probability of an event causing functional impairment once in a million years.

At the "second level", the staff contemplates that the standards would require the equipment components of the LNG facility to be classified into three categories in relation to the reliability characteristics and potential safety hazards associated with each component. According to the staff, this classification procedure would simplify design by designating different levels of safety performance for each category of components and thus enhance plant reliability and the protection **[*9]** of capital investment. The staff asserts that its proposed classification of components is particularly appropriate for California because it gives adequate consideration to earthquake-related occurrences as well as other hazards. At the "second level", the staff position is that it is unrealistic to permit the construction of an LNG facility within major fault zones where surface rupture could occur and result in a major catastrophe. The staff's proposed regulations would classify a site as "unsuitable for an LNG facility if a causative fault capable of generating a magnitude 5 or larger earthquake exists at the site."

The three categories of equipment proposed by the Commission staff are as follows:

Category I - Components which are critical in maintaining the plant in a safe shutdown condition.

Category II - Components necessary to permit continued plant operation and to provide protection against reasonably expected earthquakes and other natural and manmade hazards.

Category III - Components essential for maintaining support of normal plant operations.

At the "third level", the staff states that added reliability would be gained by requiring (a) redundancy of hazard sensors **[*10]** in critical locations, and (b) valving and other installations designed to control safely the flow or monitor the containment of LNG and natural gas throughout the plant. Under the staff concept, the first response to sensed hazards would be by a primary system which would signal for manual control. In the event of no manual response, an

automatic control system would take over. In the event of interruption of all sources of electric power, fail-safe systems would prevent any unsafe condition from further deterioration.

At the "fourth level", the staff proposal would require that the impoundment systems would collect all LNG spillage in the event of failure of containment for any reason. The impoundment system would be designed to a design-spill criterion which would provide for vapor evolution to occur at the optimum rate for safe dispersal at the plant boundary. The staff recommends a 2 percent vapor concentration criterion at the boundary line.

At the "fifth level", the staff recommendations provide that, if despite all precautions LNG should spill and ignite, fire protection equipment would be activated to mitigate or extinguish the flames. The proposed thermal exclusion **[*11]** distance requirement would call for the plant boundary to be located sufficiently far from the storage and impoundment area to prevent certain heat-flux levels reaching persons beyond the plant boundary. The staff recommends that the criterion be 1,600 Btu/ft<2>-hr. The staff states that, at this thermal flux level, persons at the property line would have at least 30 seconds to retreat from a worst-case fire.

The staff believes that the "five levels of safety" described above must be built into the design and operation of California LNG facilities prior to the day of commissioning in order to protect adequately the public safety and welfare. In addition, the staff's proposed rules contain performance requirements for the preventive maintenance procedures and for precautions to be taken during repairs.

The safety standards being considered in this investigation are the proposed revisions of Part I and Part II and a proposed new Part III (Liquefied Natural Gas Facilities Safety Standards) of this Commission's currently effective General Order No. 112-C. This general order prescribes rules governing design, construction, testing, maintenance, and operation of utility gas gathering, **[*12]** transmission, and distribution piping systems. In Exhibit No. 0-140 the staff presented its proposals for the revisions of the present Parts I and II and its proposal for the new Part III of the general order. The staff filed on February 1, 1979, with its opening brief in this phase of the proceeding an updated and corrected version of Exhibit No. 0-140, representing the staff's final recommendations on the subject. References made in this opinion to the staff's proposed safety regulations will relate to the numbering scheme used in this updated and corrected version.

Ordering Paragraph 5 of Decision No. 89177 granting Western Terminal a conditioned permit for an LNG terminal instructed the staff as follows:

"The Commission staff is directed to establish cost, environmental, and safety and construction monitoring programs for the terminal and pipeline construction authorized herein."

In response to the Commission's direction the staff introduced Exhibit No. 0-76 which presents its proposed safety and construction monitoring program for the LNG facility at Point Conception. The staff also introduced as Exhibit No. 0-164 its proposed environmental monitoring program (EMP). This **[*13]** monitoring proposal was made in response to the conditions in Decision No. 89177 related to environmental concerns. That decision includes 41 conditions to the permit granted therein. It is the staff's position that 23 of these conditions relate to environmental matters and are, therefore, wholly or partially the concern of the EMP.

No alternatives to the staff's monitoring proposals were presented by any other party during the hearings in this proceeding. The staff of the CCC presented a recommendation for a review panel to be incorporated into the Commission staff's proposal. The utilities did not present an alternative proposal during the hearings; however, they submitted as appendices to their opening brief, extensive and comprehensive recommendations for modification of the staff's monitoring proposals.

B. Respondents' Position

Western Terminal and SoCal (hereinafter referred to as respondents) have made numerous technical recommendations for the proposed regulations on the basis that they are reasonable and consistent with the public health, safety, and welfare. Respondents' final proposals for the regulations governing the safety and construction of LNG terminals **[*14]** are set forth in Appendices A and B to their opening brief. Their proposal for the safety, construction, and EMPs are set forth in Appendices C and D to that brief. Respondents' position will be presented below for each of the numerous technical issues arising from the staff's proposals.

C. SDG&E's Position

As the operator of the only existing LNG facilities in California that will be affected by the LNG safety standards, SDG&E has two major areas of disagreement with the staff's proposal. SDG&E regards these two issues to be of paramount importance. These issues impact SDG&E uniquely because they concern the manner in which SDG&E's facility will be grandfathered under the proposed regulations. The two issues are: (1) the general question of "applicability", i.e., to what extent the regulations apply retroactively to SDG&E's existing LNG plants; and (2) the need for and type of LNG tank inspection necessary for safety.

On the issue of applicability, SDG&E takes the position that its plants would be most logically governed by: (1) the design standards in National Fire Protection Association Standard 59A, "Standard for the Production, Storage and Handling of Liquefied Natural **[*15]** Gas (LNG)" (NFPA 59A) n5 the code under which its plants were built and approved by the Commission; and (2) by the operating requirements in the LNG terminal safety regulations to be established by this decision.

n5 The 1975 edition of this code is included in this record by reference as Item O-FF. The proposed amendments to this edition of National Fire Protection Association, scheduled for adoption in 1979, are included in the record as Item O-BBB.

On the issue of tank inspection, SDG&E asserts (1) that periodic direct inspection of the integrity of the inner LNG tank material is not necessary; (2) that the only technically feasible method for such inspection available today (internal tank entry) is prohibitively expensive, hazardous, and unwarranted; and (3) that completely satisfactory external methods of inspection are currently in everyday use.

On the other issues, generally, SDG&E supports the position taken by Western Terminal and the other respondent utilities, and SDG&E supports respondents' proposals as to the form of order for the proposed revisions of General Order No. 112-C. However, on a few of the other technical issues SDG&E has its own points of view which are **[*16]** discussed below under each of the areas which give SDG&E particular concern.

D. CCC's Position

In its participation in this phase of proceedings, the CCC focused on two areas which the CCC staff takes issue with the proposed safety regulations. The CCC staff recommends:

1. The establishment of an interdisciplinary review board of unquestioned integrity and independence, capable of achieving the maximum amount of public confidence, and

2. The inclusion of certain structural design requirements related to the geologic conditions which are not contained in the staff's proposed safety regulations but which, in the view of the CCC staff are necessary to ensure public safety.

The CCC staff recommendations as to structural design requirements are discussed herein under geologic and seismic issues. As to the proposal that this Commission establish an interdisciplinary review board as part of the construction monitoring program, the CCC staff presented the general concept during the hearings in Phase II of the proceedings; however, it was not presented in formulated, concrete terms until it was submitted as a proposal in the CCC staff's opening brief. The other parties were not **[*17]** afforded an opportunity to respond during the hearings.

As proposed in the CCC's opening brief, it is evident that the proposed procedures would be costly and result in excessive delays. The process would be subjected to formal, time-consuming notice, hearing and appeals requirements, which would stretch out the time required for the decision-making process.

The staff's monitoring program will address the same issues as the proposed review board. In this respect the CCC staff proposal is in conflict with the staff's proposed monitoring program.

The CCC staff proposal is substantially the same as that submitted to us in Application No. 57626 by the CCC in its proposed Condition 14. Our Decision No. 89177 held as follows with respect to that proposal:

"The operation and funding of an independent terminal design and construction review panel in addition to the funded Safety and Construction Monitoring Program of this Commission, would be unwarranted and uneconomical. It would be an unnecessary duplication of expert effort, investigation, and review. The Commission's Safety and Construction Monitoring Program will employ a permanent staff of professionals as well as utilize consultants. **[*18]**

Our monitoring program will assure that the construction drawings and calculations are thoroughly reviewed and that the construction is adequately inspected."

We will affirm the position we took in our July 31, 1978 decision by rejecting the CCC staff's proposal for an interdisciplinary review board.

III. UNRESOLVED ISSUES RE THE PROPOSED SAFETY STANDARDS

Following preparation of the initial draft of the staff's proposed safety standards, a series of extended technical conferences were held between respondents and the Commission staff. These conferences were public meetings which were noticed at the hearings in this proceeding and to which the parties and any other members of the public were invited to attend and participate. Through the mechanism of these conferences many of the technical issues regarding the safety standards were resolved, thereby greatly reducing the number of issues requiring resolution herein. The ensuing discussion in this opinion is confined to the relatively few significant issues which are still outstanding.

The section, subsection, and appendix numbers used in the opinion portion of this decision are those used by the staff in its proposed regulations **[*19]** (Exhibit No. 0-140). To the extent that there have been deletions and additions of text, the numbering of the sections of the regulations as finally adopted herein will, of course, differ in some instances from the numbering used by the staff in its proposal.

A. Part I, Subpart C - Reports

At Subpart C of Part I of General Order No. 112-C, the staff proposes that Section 143 be added. Section 143, as proposed, would require LNG facility operators to file certain reports with the Commission. While respondents do not oppose most of the reporting requirements contained in Section 143, they strongly urge that Subsection 143(d) not be adopted. n6 They also urge modification of Subsection 143(i).

n6 Not adopting Subsection 143(d) would obviate the need for Appendix C of Part III of the staff proposal. This appendix prescribes the format of the Final Safety Analysis Report (FSAR).

1. Subsection 143(d)

This subsection would require each operator to file with the Commission, at least 90 days before initial cooldown of an LNG facility, an FSAR.

The staff asserts that the FSAR is an integral part of its proposed "Safety and Construction Monitoring Program". (Exhibit No. **[*20]** 0-76, Chapter 7.) A staff witness summarized the intended purpose of the FSAR to be as follows:

"The principal purpose of the FSAR will be to inform the Commission of the nature of the LNG plant, description of its operations, and the safety evaluations and testing that have been performed to protect the health and welfare of the public.

"The FSAR is the principal document which should provide the information needed to understand the basis on which the facility is designed and constructed.

"The FSAR will be utilized to demonstrate that the constructed facility would operate within the licensed conditions."

The record, however, does not support the need to file the FSAR with the Commission. Neither the Act nor Decision No. 89177 suggests that an FSAR be required. Most of the extensive documentation to be contained in the FSAR would have been previously submitted to the Commission pursuant to the requirements of the proposed construction monitoring program and Subsection 143(c) of this part. The record demonstrates that the FSAR would be unnecessary and burdensome. Further, as proposed, Subsection 143(d) suggests that the Commission could disapprove Western Terminal's facility when **[*21]** construction is completed and that Commission action, or inaction, on the FSAR could delay commencement of operations indefinitely. This prospect could seriously threaten the financing of the facility, if lenders should view the project as not having final approval from the Commission until the FSAR is ultimately approved.

The adopted regulations will not require the operator of an LNG facility to file an FSAR.

2. Subsection 143(i)

This proposed subsection would require each operator to file reports with the Commission under the following circumstances:

"Except for failure reported in a leak report under 49 CFR Part 191, each failure of a critical component caused by corrosion which occurs before the end of the component's service life shall be reported to the Commission within 30 days after the failure."

Respondents would substitute the word "major" for the word "critical", asserting that the wording as proposed is so vague as to render it unreasonably broad and meaningless. They contend the term "critical component" can be interpreted to include almost every minor component in an LNG facility.

In Section 193.5 of Exhibit No. 0-140, the staff proposes the following definition: **[*22]**

"'Critical component' means a component which may cause, fail to prevent, or increase a hazardous condition if its operational capability is impaired or malfunction occurs."

In our opinion the substitution of "major component" for "critical component" would in no appreciable manner increase the specificity of Subsection 143(i). Respondents proposed substitute word is at least as vague as the staff term. While the word "major" might, in some instances, eliminate the reporting of unimportant failures, we do not believe that the possibily greater reporting requirement to be occasioned by the word "critical" would significantly burden the LNG operator.

To the extent that the term "critical component" suffers from vagueness, the staff, in its opening brief outlines a reasonable procedure by which it would undertake to overcome any resulting problem. Toward this end, the staff would proceed as follows:

"As in other subsections that deal with critical components, the specific components to be considered 'critical' for the purposes of this subsection should be proposed by the operator and reviewed by the staff after the design for each particular LNG facility is finalized."

For the reasons **[*23]** discussed above and under Section 193.1307, we will adopt the staff's proposal for Subsection 143(i).

3. Subsection 143(j)

The staff's recommended Subsection 143(j) requires operators of both existing and new LNG facilities to file with this Commission the hazard analysis evaluation required by Section 193.1307 of Subpart N. The utilities propose adding the words "or required by Section 193.3(c) of Appendix A."

The reason for this proposed revision is apparent. As discussed below, Section 193.1307 requires an operator to prepare a hazard analysis evaluation. Subsection 193.3(b) applies the requirements of Subpart N and consequently the hazard analysis evaluation requirement of Section 193.1307, to existing facilities. Respondents have proposed deleting the reference to Subpart N in Subsection 193.3(b). This deletion would relieve existing facilities of the requirement to comply with that subpart. The utilities would also replace the staff's Subsection 193.3(c) with their own version. The utilities' version of Subsection 193.3(c) would relieve existing facilities of the requirements of Subparts C through K and P and substitute compliance with the NFPA Standard 59A applicable **[*24]** at the time of construction of the facility as well as the next following edition of that standard. The utilities proposed addition to Subsection 143(j) would, therefore, substitute a hazard analysis evaluation that may be required by the 1979 version of NFPA 59A for the staff's hazard analysis evaluation recommended in Section 193.1307 as the study to be filed for existing facilities. For the reasons set forth under Section 193.1307, we will not adopt the utilities' suggested modification to Subsection 143(j).

B. Part III, Subpart A - General

1. Section 193.3 - Applicability of Part

Section 193.3 contains provisions concerning the applicability of the proposed Part III of General Order No. 112-C. Subsection 193.3(a) states that the entire Code applies to new LNG facilities and to existing facilities which are relocated, replaced, or which undergo a majorfunctionalmodification. SDG&E agrees with the staff that this is an appropriate requirement. As proposed by the staff, Subsection 193.3(b), (c) and (d) read:

(b) "Existing facilities shall comply with requirements for Reporting (Subpart C of Part I), Operations (Subpart L), Maintenance (Subpart M), and Hazard **[*25]** Control Systems (Subpart N) starting one year after the adoption of these standards. Existing facilities shall comply with the Requirements for Corrosion Control as specified by Subpart I, Part II of this General Order."

(c) "TThe requirements in Subparts C through K and P of this part for the modification, repair or replacement of critical component within facilities which are in operation on the effective date of this part, shall apply to the component modified, repaired or replaced to the extent practical."

(d) "For those facilities exempted above, the applicable requirements of Part II of this General Order pertaining to LNG facilities on the day before the effective date of this part shall continue to be acceptable for that facility, so long as the above exemptions (a), (b) and (c) apply."

The utilities concur with the application of the requirements of Subsection 193.3(b) insofar as they relate to reporting, operations, and maintenance. As to the requirement for compliance with Subpart N, the utilities agree that they should comply with requirements similar to those in the staff's proposal. However, as indicated above in the discussion of Subsection 143(j), the utilities **[*26]** have certain problems with the staff's proposed Section 193.3. Therefore, the utilities also revised Subsections 193.3(c) and 193.3(d) to exempt existing facilities from complying with these requirements.

For the reasons discussed under Section 193.1307, we will adopt the staff's proposals for Subsections 193.3(b), 193.3(c) and 193.3(d).

2. Section 193.5 - Definitions

a. Cargo Transfer System

The staff proposes the following definition:

"'Cargo transfer system' means a component or system of components and associated area for transferring flammable fluids or cryogenic refrigerants in bulk between the closest inline valve on transfer piping and a tank car, tank truck, marine vessel, or pipeline, including connections, arms, hoses, the area in which a tank car, tank truck, or pipeline is located during transfer, and the area in which a marine vessel is located."

The significant place at which the term "cargo transfer system" appears in the proposed regulations is Section 193.611, which imposes exacting design requirements for such systems to ensure their integrity. Staff Section 193.611 has been drafted so that cargo transfer systems would be designed and constructed to very **[*27]** stringent standards to prevent the accidental release of LNG.

Respondents contend that the term "cryogenic refrigerant" as used in the above definition "simply says too much." Respondents would modify the definition of "cargo transfer system" by the deletion of "flammable fluids and cryogenic refrigerants" and by the substitution of "LNG or flammable refrigerants."

We agree with respondents on this point. The modified definition which they propose for the term "cargo transfer system" will be adopted.

b. Critical Component

The term "critical component" appears in five sections of the staff's proposed safety regulations: Section 143(i) of Part I and Sections 193.3(c), 193.139, 193.1105(h)(2), and 193.1125(b) of Part III. Under the staff proposal, the particular components that are to be considered "critical" would, in most cases, be determined by the operator during the facility design phase. The operator's determination would then be finalized in consultation with the staff. It is necessary, according to the staff, that certain components be considered "critical" so that during design, construction and operation, the operator must apply appropriately higher standards in the **[*28]** design, purchase, and maintenance of the designated components. We are of the opinion that this special attention will contribute to the operational safety of LNG facilities. Therefore, we will adopt the staff's proposed definition.

Further discussion of the term "critical component" and its implications is included in this opinion under Subpart N, Section 193.1307.

c. Design Basis Flood

Respondents urge that the definition of "design basis flood" as it appears in Section 193.5 of the staff's proposed regulations, not be adopted. The term appears at only one place, Section 193.127, in the proposed regulations, and it is clearly defined there. It would serve no useful purpose to define a term generally for a set of regulations when it has such limited use within the body of regulations.

We will delete the definition of "design basis flood" from the adopted regulations.

d. Flame Spread Rating

Respondents recommend the addition of a definition for the term "flame spread rating." They point out that the staff has used the term "limited combustible" within its proposed regulations, e.g., Section 193.217, which would require LNG terminal operators to use noncombustible or **[*29]** limited combustible materials in the construction of certain improvements. The staff has defined the latter term in proposed Section 193.5, Definitions. Respondents argue that, although that definition employs the phrase "flame spread rating," it provides no guidance as to how those ratings are to be measured. Respondents recommend the addition of the following definition of "flame spread rating," which references an accepted industry test for measuring the ratings:

"'Flame spread rating' refers to the numbers or classifications obtained according to the Method of Test of Surface Burning Characteristics of Building Materials (NFPA 255)." n7

n7 The Commission has taken official notice of National Fire Protection Association publication NFPA 255, 1972 edition, and has incorporated it into this record by reference as Item No. O-KKK.

We will adopt respondents' recommendation.

e. Flammable Gas

Respondents also recommend the addition of a definition for the term "flammable gas" to the regulations. The term "flammable gas" appears in several of the staff's proposed regulations, e.g., Section 193.307; however, the staff has not proposed a definition for the term. Respondents **[*30]** recommend that the following definition be included in the adopted regulations to avoid confusion:

"'Flammable gas' is any gas which will burn in the normal concentration of oxygen in the air."

The definition proposed by respondents is consistent with accepted usage. It will add clarity to the regulations and will be adopted.

f. Flammable Limits

The staff's proposed regulations contain the following definition:

"'Flammable limits' are the lowest and highest concentration of a specific gas or vapor in a mixture with air that can be ignited."

Respondents believe that the staff's proposed definition suffers somewhat from ambiguity and should be modified. They point out that the staff's proposed definition of "flammable limits" contains no reference to atmospheric pressure and temperature. In this form, its application might cause limits to be established at unreasonable, and probably unintended, extremes. Respondents have, therefore, proposed the following modified definition:

"'Flammable limits' are extreme concentration limits of a combustible in air through which a flame, once initiated, will continue to propagate at atmospheric pressure and temperature."

The modification **[*31]** of the definition, as proposed by respondents, is appropriate, and it will be adopted.

g. Geologic and Seismic Definitions

(1) Capable Fault

In its opening brief, Western Terminal proposes an alternative definition of "capable fault" which is somewhat at variance with the staff's proposed definition. It is apparent that Western Terminal's proposed alternative results in part from interpretation of the testimony of the staff's geology consultant, Dr. James Slosson, and the CCC's consultant, Mr. George Brogan. The staff concedes that the alternative proposed by Western Terminal is better suited to the geologic setting peculiar to California, and it agrees that the new definition is preferable to its original proposal.

The staff states in its reply brief that, therefore, it is now proposing that this Commission adopt the following revised definition of "capable fault":

"A 'capable fault' is a fault which has exhibited one or more of the following characteristics:

"(a) Faulting at or near the ground surface within the past 100,000 to 140,000 years with consideration given to evidence of displacement or lack of displacement of earth materials and/or geomorphic features formed **[*32]** during that time frame. Other scientific techniques that provide a high level of confidence may be applied.

"(b) A clustering of earthquakes (3 magnitude or greater) instrumentally located with records of sufficient precision to demonstrate a casual relationship between the faults and the earthquakes.

"(c) A structural relationship to a capable fault according to characteristics (a) or (b) of this paragraph such that movement on one could be reasonably expected to be accompanied by movement on the other.

"In some cases, the geologic evidence of past activity at or near the ground surface along a particular fault may obscured at a particular site. This might occur, for example, at a site having deep overburden (alluvium, colluvium, landslide debris, etc.). For these cases, evidence may exist elsewhere along the fault from which an evaluation of its characteristics in the vicinity of the site can be scientifically based. Such evidence shall be used in determining whether the fault is a capable fault within this definition. Structural association of a fault with geologic features which are geologically older than Quarternary, such as many of those found in California, shall, in **[*33]** the absence of conflicting evidence, demonstrate that the fault is not a capable fault within this definition."

The staff offers the following rationale in support of this new definition:

"The 35,000 year criterion for a single movement at or near the ground surface may be too short a time frame for determining whether a fault is active or inactive. The staff's original definition would have required determination of movements of a recurring nature within the past 500,000 years. The record shows that it may be too difficult to determine such recurring movement at most California coastal sites. The criterion of 100,000 years to 140,000 years is a reasonable time factor to consider in determining whether a fault is active or inactive. Isotope dating may create certain limitations. There are, however, other equally valid scientific techniques for dating the terrace deposits as well as wave cut platforms for the 100,000 to 140,000 year time frame.

"The wave cut platforms and marine terrace deposits along the California coast are fairly uniform. The relative dating for a series of wave cut platforms and marine terraces has been established and cataloged, and time equivalencies of **[*34]** such platforms and terraces can be extrapolated laterally along the coast of California. The contained materials within the terrace deposits overlying the wave cut platforms can be dated if certain materials are present. The terrace deposits or wave cut platforms materials may be fairly uniform along the coast for long distances. Platforms or terraces which are in the range of 80,000 to 140,000 years are present along the coast.

"The Bureau of Reclamation has made a decision to use a 100,000 years criterion for dam design. The Bureau uses soil dating and isotope dating techniques. This is a workable method for the coastline of California as their use makes it easier to date the materials in California. Stream cut features or stream deposits can also be dated similarly.

"The staff believes that this new definition of 'capable fault' is a definite improvement over NRC recommendations. The dual approach which the NRC uses is somewhat difficult to apply in many geologic settings in California. So, it is strongly recommended that the new definition of 'capable fault' as set forth above be adopted for use in these LNG safety standards."

We will adopt the revised definition of "capable **[*35]** fault" as proposed in the staff's reply brief.

(2) Causative Fault

As proposed by the staff, "A 'causative fault' is a capable fault which has or may in the future generate an earthquake of greater than 5.0 magnitude."

Because the term "causative fault" is used as a site exclusion criteria, it will be discussed in relation to the staff's proposed Subsection 193.115(f) - Seismic Design Criteria, which provides, in part, that "If the investigation indicates that a causative fault capable of generating a greater than 5.0 magnitude earthquake trends through a proposed LNG site, the site shall be considered unsatisfactory as an LNG site."

The record before us demonstrates that the final determination of the suitability of a site should consider the potential external hazards bearing upon a terminal at the site and the engineering capability of dealing with such hazards including the cost thereof. The concept of "causative fault" and its use as a site exclusion criteria in Subsection 193.115(f) would, however, tend to give consideration only to external hazards without adequate recognition of the engineering and economic aspects of coping with such hazards.

Respondents argue that **[*36]** existing engineering technology can provide seismic designs for both the vibratory ground motions and several feet of fault displacement which may be associated with a "causative" fault. They further urge that the concept of causative fault, as proposed, is not readily applicable and would not be useful as a regulatory tool. Instead, they argue, the concept tends improperly to oversimplify a group of issues which require case-by-case evaluation.

The staff concept of causative fault was sponsored by Dr. Slosson. Initially, Dr. Slosson suggested that inclusion of the concept of causative fault in the regulations was the result of both geologic and engineering input. He testified that he is concerned with both the ground shaking and the potential surface rupture associated with an on-site causative fault. According to Dr. Slosson, the potential ground shaking associated with such a fault should eliminate a site containing a causative fault from further consideration. He testified that his definition of and use of the concept of causative fault, associated with a magnitude 5 or greater earthquake, is not based upon the statements of structural engineers, but rather reflects his professional **[*37]** opinion. Thus, the record shows that the concept is not the product of an engineering rationale, but it is, instead, the reflection of a geologist's concept of land use planning.

The evidence of record clearly shows that engineers are able to design for the ground shaking that would be produced by greater than magnitude 5 earthquakes which could occur in close proximity to a prospective plant site. Expert engineers appearing for all of the active parties during the Phase II hearings--not only engineers produced by the respondents, but Dr. George Young for the staff and Henry Degenkolb for the CCC--testified that engineers can and do design for such vibratory ground motion.

Dr. Young, the staff's seismic engineering consultant, testified to the effect that, since the engineering profession is designing structures for magnitude 7.5 earthquakes, it obviously can design for the ground shaking associated with a magnitude 5 or greater earthquake. With regard to fault rupture, Dr. Young stated, "If you ask me as a design engineer, can we design the structure to rest on a fault, I would say, yes, but it is going to require some very special design and we should all recognize we are in an **[*38]** area of great uncertainty."

Dr. Nathan Newmark, an engineer in the field of seismic design of structures who has served as a long-time consultant to the Nuclear Regulatory Commission (NRC) appeared on behalf of respondents. He stated, both in direct testimony and under cross-examination that the engineering profession can design for surface displacement. Dr. Newmark also noted that engineering precautions which are properly applied to NRC facilities are not necessarily applicable to LNG facilities. He explained that, because of the differences between nuclear power plants and LNG plants, certain design provisions for the two types of facilities should likewise be different. In this respect, Dr. Newmark stated:

"Certain equipment in nuclear reactor structures, including especially the reactor pressure vessel and its support, can tolerate only minor permanent tipping or tilting. Consequently it is a valid requirement that nuclear reactor facilities containing such items not be situated directly over or very near a fault with a potential motion of more than a very few inches unless special precautions are taken in the design.

". . .

"With LNG facilities, the sensitive parts of the **[*39]** system to relative surface displacements are the walls of the storage tank, but only if there is a relative displacement of several inches occurring over a very short distance in the wall. The tank would have practically no difficulty in surviving, without damage, even as much as several feet of relative vertical displacement occurring uniformly across its entire diameter. Consequently, LNG storage tanks could be located directly over potential surface relative displacement of a few inches if the tank foundation is specially designed to accommodate the potential displacement. Trestles, piers, piping, etc., especially when above ground, can survive, without failure several feet of relative surface motion if properly designed, and designs to resist from five feet to 20 feet of fault motion have been made for piping system, both above and below ground."

We conclude from the foregoing that the proposed definition and use of the term causative fault are not supported by a proper engineering rationale. The engineers who testified on this question are unanimous in their view that the engineering profession can design for vibratory ground motion associated with a magnitude 5 and greater **[*40]**

earthquake. In addition, there is the testimony of an expert geologist that the term causative fault, as defined and used in the staff's proposed version of the regulations is inappropriate. Dr. James Davis, the State Geologist, stated in his prepared testimony and during cross-examination that he agrees with the respondents' deletion of the term causative fault. He expressed the belief that the site suitability decisions should be made following review of all information available as a result of geological investigation, such as those required by Subpart B, Section 193.115 and that site suitability decisions should be made on a case-by-case basis. Dr. Davis stated that the term causative fault does not assist materially in determining site feasibility. He said that his opinion would not change even if the term were modified to mean a fault associated with a magnitude 6 or larger earthquake.

The record as made in this safety investigation will not support a determination of the engineering necessity and geologic propriety of incorporating into the adopted safety regulations the concept of causative fault, as that term is defined and used in the proposal. No engineering or geologic **[*41]** rationale was developed to support the proposition that the geologic suitability of a site should be determined on the basis of the single criterion such as the proposed concept of "causative fault." The concept has been rejected by the majority of the seismic experts who testified before us in this investigation.

We will delete the definition of "causative fault" from Section 193.5, and we will appropriately modify Subsection 193.115 (as well as Appendix B to the proposed regulations) to remove the term as a criterion for site exclusion.

(3) Secondary Fault

Proposed Section 193.5 contains the following definition:

"A 'secondary fault' is a sympathetic or subsidiary fault which ruptures peripherally to the causative fault and/or its splays. It is a non-causative fault which ruptures in response or sympathy to an earthquake and rupture on a nearby causative fault. Other terms which may be synonymous are: sympathetic, antithetic, tear, second order, some en echelon faults and faults related to anticlinal folding.

"For the purpose of these regulations, a secondary fault is less than one (1) mile in length, peripheral to the causative fault or its splays, separated from the causative **[*42]** fault or its splays, separated from the causative fault or splays by at least one mile, and there is no direct evidence of connection at depth with the causative fault or any of its splays.

The staff's geologic expert, Dr. Slosson, testified that this term has been included in the proposed regulations to differentiate between causative and secondary faults (i.e., faults not capable of generating earthquakes greater than magnitude 5), and thereby indicate that the presence of secondary faults on a site does not preclude that site for use as an LNG terminal.

Respondents take the position that the term secondary fault should be eliminated from all sections of the proposed safety regulations including Appendix B thereto. Since the purpose of including the term secondary fault is to distinguish certain types of faults from those defined as causative, and since we are excluding the term causative fault from the proposed safety regulations, we shall likewise exclude all use of the term secondary fault.

h. Safety Related Components

The staff's proposed regualations contain the following definition of the phrase "safety related components":

"'Safety related components' are components **[*43]** whose function is to maintain a safe operating or shutdown condition and to prevent or control hazardous conditions in case of an emergency."

Respondents recommend the rejection of this definition "simply on the basis that it is so vague as to render it meaningless in this rulemaking." Respondents argue that, logically, any "component," such as the light switch or the doorknob to the control room, could be found to be a "safety related component" because, under readily postulated circumstances, any component could arguably be said to have a function of maintaining a safe operating condition. Respondents maintain that the proposed definition would in no way assist the staff or the terminal operator to understand the application of the regulations in which the term "safety related component" is employed.

According to the staff, it is crucial that components, structures, and systems performing safety functions be properly identified and categorized as early as possible in the design process to make this identification and to achieve the levels of safety proposed by the staff, the staff regards retention of this definition as essential.

The staff witness on this definition testified **[*44]** that safety related components are those components which are crucial for maintaining the facility in case of an emergency in a safe shutdown or safe operating condition depending upon its design function. (Emphasis added.)

We will adopt the staff definition, modified to read as follows:

"Safety related component is a component the function of which is crucial to the maintenance of a safe operating or shutdown condition and to the prevention or control of hazardous conditions in an emergency."

i. Transfer Area

Respondents recommend the modification of the definition of the term "transfer area" in the same manner and for the same reasons as they set forth in connection with the definition of "cargo transfer system."

Adoption of respondents' proposed definition would remove liquid nitrogen from the purview of this definition. The record demonstrates that its inclusion within that definition would impose unnecessary design and construction requirements; therefore, respondents' recommendation will be adopted.

j. Transfer Piping

Respondents also recommend the modification of the definition of the term "transfer piping" in the staff's proposed regulations in the same manner **[*45]** and for the same reasons as set forth above in connection with the definition of "cargo transfer system." Again, it is respondents' position, and we agree, that the record clearly shows that the inclusion of liquid nitrogen within the purview of the definition of "transfer piping" would produce unnecessary design requirements under the staff's proposed regulations. We will adopt respondents' recommendation for the definition of this term.

C. Part III, Subpart B - Facility Design and Siting Criteria

Respondents suggest that the above title be substituted for the title contained in the staff proposal: "Design for Natural and Manmade Hazards".

In our opinion respondents' suggestion does not describe the contents of Subpart B, as adopted herein. We will, therefore, adopt the staff's proposal for the title for this subpart.

1. Section 193.103 - Natural and Manmade Hazards

This section, as proposed by the staff, lists certain natural and manmade hazards. By itself, Section 193.103 imposes no requirements on LNG terminal operators. However, when read with Section 193.105, as proposed by the staff, the operator would be required to consider all the hazards listed in Section 193.103 **[*46]** unless they satisfy the exclusion criteria set forth in Section 193.105.

Respondents recommend that Section 193.103 not be adopted. They point out that Section 193.105 requires the operator to design for the hazards listed in Section 193.103 "and other hazards identified for a particular site"; and that by containing such a list the regulations would require operators to analyze or consider, for design purposes, hazards which are obviously not present at a given site.

Respondents further point out that Section 193.103 contains the following "external manmade hazards", "graded slopes, "engineered fill," and "foundation", which are clearly not external hazards in and of themselves. Respondents contend that the inclusion of such hazards within Section 193.103 implies that the design and construction of an LNG facility is itself one of the hazards that must be designed against. We agree with respondents that the three terms should be deleted from Section 193.103.

However, the remainder of Section 193.103 is needed to identify the hazards for consideration in Section 193.105. We will adopt Section 193.103 as proposed with the modification discussed above.

2. Section 193.105 - Exclusion **[*47]** Criteria

As proposed by the staff, this section of the proposed safety rules provides:

"The design of an LNG facility shall include the possible effects of hazards listed in Section 193.103 and other hazards not identified for a particular site unless they meet the exclusion criteria listed below:

"(a) A hazard which is proved by the operator not to be significant relative to other hazards which are considered as a design basis.

"(b) A hazard which by itself has a probability of functional impairment to a safety related structure or system of less than 10<-6> per year. The probability of functional impairment will generally be equal to the product of the probability of occurrence of the particular hazard event and the conditional probability of significant impairment of function or significant structural or system failure given the occurrence of the hazard event."

As its title indicates, Section 193.105 utilizes the concept of exclusion criteria. In substance, this section requires the terminal operator to design for each of certain hazards unless the particular hazard can be excluded because it meets both of the following tests: (1) it is proved not to be significant relative **[*48]** to other hazards which are considered as a design basis, and (2) it has a probability of causing functional impairment to a safety related structure or system of 10<-6> per year n8 or less.

n8 A probability of 10<-6> per year, put more directly, means that an event has a likelihood of causing functional impairment once in one million years.

The staff approach is to divide overall risk into two major components. One of these is the probabilistic component which includes the probability of occurrence of the hazard and the related probability that a system or component failure may occur due to the occurrence of the natural or manmade hazard. This risk can be reduced by imposing conservative design to reduce the probability of failure due to the hazard. The staff states that its selection of the exclusion criterion of 10<-6> is based on an analysis presented in Technical Report No. 16 of the Point Conception Environmental Impact Report (Exhibit No. 0-53). That report expresses risk to the public created by an LNG terminal as the expected number of fatalities per year of operation. The risk analysis contained in the report concludes that the probability of one or more fatalities **[*49]** due to all causes, including LNG shipping accidents, is less than 2 x 10<-6> per year. The probability of twenty or more fatalities is less than 1 x 10<-8>. The risk analysis finds that the greatest source of risk to the public results from ship-related accidents where the probability of spills from one and two LNG tankers is 7 x 10<-5> and 3 x 10<-6> per year, respectively. Thus, according to the staff reasoning, consideration of risks to the onshore facilities with probabilities less than 1 x 10<-6> would not significantly decrease the expected fatalities per year.

The other major component of risk in the staff approach is associated with a given system or component failure which may cause serious consequences--injury or loss of life and property. The LNG safety regulations must provide mitigation measures to confine or reduce such dangers. Examples of such mitigation measures are impoundment requirements, thermal radiation criteria, exclusion distances, vapor dispersion criteria, fire protection systems, and emergency shutdown systems. None of these are included in the exclusion criterion of 10<-6>.

The staff position is that the use of the probability of functional impairment **[*50]** of 10<-6> to a safety related structure or component would provide a uniform approach as to what level of functional impairment should be included in the design for natural and manmade hazards. The proposed section does not indicate what level the operator should design to meet when an event that could result in functional impairment is within the 10<-6> criterion. The section provides a formula which specifies that the probability of functional impairment will be equal to the product of the probability of occurrence of a particular hazard event and the probability of significant impairment of function. n9

n9 The source of this formula is an NRC report entitled "An Assessment of Accident Risks in U.S. Nuclear Plants" (Wash. 1400). This report is incorporated in the record of this proceeding as Item 0-ZZ. It should be noted, however, that the NRC has not adopted probability based exclusion criteria such as the staff here proposes.

Under the staff's proposal, LNG storage tanks and other critical components would be designed so that each factor which might result in a catastrophic failure (e.g., seismic, tornado, etc.) has a 99.5% probability of not being exceeded in 50 years. **[*51]** This represents a design event which has a recurrence interval of approximately 10,000 years or a probability of occurrence of about 10<-4> per year. There is about a 1% chance (conditional probability of failure equal to 10<-2> per year) of an actual failure occurring if the design conditions should occur. Because of conservatism inherent in the design of tanks and other critical structures or systems. The probability of functional impairment to critical structures or systems is, therefore, equal to 10<-6> per year.

The staff in its Exhibit No. 0-141 advises us that the U.S. Department of Transportation in its Advance Notice of Rulemaking proposed that LNG storage tanks and other critical components be designed so that each factor which might result in a catastrophic failure (e.g., seismic) has a 99.5% probability of not being exceeded in 50 years.

The staff considers the exclusion level proposed in its Section 193.105 to be the most important single element in the safety standards for providing uniform protection against natural and manmade hazards. Respondents, on the other hand, urge that this section in its entirety be deleted from the safety standards.

The respondents' objection **[*52]** to the staff's proposed Section 193.105 is directed at the exclusion criterion of 10<-6>. The record shows, however, that the respondents do not object to the establishment of a design criterion of 10<-4> for hazards covered in various sections of Subpart B which are not of issue herein. The respondents' fundamental problem with Section 193.105 is that it would require that important decisions for exclusion criteria be made solely on the basis of the mathematical result of certain risk analyses. They argue that risk analysis is not an exact science and that two competent experts performing risk analyses for the same hazard at the same site could reasonably arrive at widely different results. Respondents contend that, while such analyses are very useful to regulatory agencies when considering proposed projects on a case-by-case basis, they are not appropriate as the arbitrary sole determinant for exclusion criteria as the staff proposes.

We agree that probability analysis as contemplated by the staff would not be suitable to determine exclusion criteria. Probability analysis is not a sufficiently exact science to be used in the manner proposed by the staff. The results of risk **[*53]** analysis are, at best, comparative values; they are not absolute values which can be properly imposed by these regulations. The record shows that no federal or state agency has adopted probability-based exclusion criteria.

However, the evidence leads us to conclude that we should allow the use of the probabilistic concept in a design criteria. We concur with the staff that the probability concept is a useful complement to the traditional deterministic criteria. Furthermore, the probability criteria will provide a uniform design level for all hazards that might affect the facilities. We will, therefore, adopt a design criteria which utilizes probabilistic as well as deterministic concepts in Section 193.105.

Furthermore, we concur with the staff proposal appearing in Section 193.121 (not at issue herein) that the components of an LNG facility should be classified into three categories in relation to the reliability characteristics and potential safety hazards associated with each component. The classification procedure will simplify design by designating different levels of safety performance for each category of components and thus enhance plant reliability and the protection **[*54]** of capital investment. However, we disagree with the staff position that such classification should be applicable to seismic design only. We are of the opinion that the use of these three classifications of components should be broadened to apply to all natural and man-made hazards. This will provide uniform design levels for natural and man-made hazards, enhance plant reliability and protect capital investment. We will, therefore, revise Sections 193.105 and 193.121 as follows:

193.105 General design criteria

The design of structures, components, and systems of an LNG facility shall include the possible effects of hazards listed in Section 193.103 and other hazards identified for a particular site according to the classification system required in subsection (a) below.

(a) Classification of Structures, Components, and Systems

All structures, components, and systems important to normal LNG facility operations shall be classified into one of three design categories that are defined as follows:

(1) Category I: All structures, components, and systems which perform a vital safety-related function, including the LNG storage containers, their impounding systems, and hazard **[*55]** protection systems, shall be classified Category I. All Category I systems shall be designed for each natural or man-made hazard which has a probability of occurrence of 10<-4> per year, or be designed for each such natural or man-made hazard using the deterministic methods specified for Category I structures in this subpart.

(2) Category II: All structures, components, and systems not included in Category I which are required to maintain continued safe plant operation during and following any natural or man-made hazard which has a probability of occurrence of less than 2 x 10<-3> per year shall be classified Category II. All category II systems shall be designed for

the event with a probability of 2 x 10<-3> per year or be designed for each such natural or man-made hazard using the deterministic methods specified for Category II structures in this subpart.

(3) Category III: All structures, components, and systems not included in Categories I and II, but which are essential for maintaining support of normal plant operations, shall be classified Category III. Category III items shall be designed in accordance with the provisions of the UBC, ANSI, API, or other applicable **[*56]** national, state, or local standards and codes.

(b) Supporting Elements

A structure, component, or system of a given category may be supported by a structure classified in a different category, provided it is demonstrated that the supported item can maintain its functional requirements specified by its design category.

(c) Listing of Classification

The operator shall provide a complete listing of the recommended classification of all structures, components, and systems for review.

193.121 Safety function of structures, components, and systems

Categories I and II structures, components, and systems of LNG facilities classified in accordance with Section 193.105 must be able to perform their safety function as follows:

(a) Category I: Items in this category must be able to--

(1) Perform their safety function without repair during and following the SSE; and

(2) Remain operational during and following the OBE.

(b) Category II: Items in this category must be able to--

(1) Operate without repair following the OBE; and

(2) Withstand the effects of the SSE without loss of structural integrity.

3. Section 193.109 - General

As proposed, Subsection 193.109(a) specifies **[*57]** factors to be considered in selecting LNG terminal sites. At Paragraph 193.109(a)(2), the prospective terminal operator would be required to consider:

"Factors applicable to the particular situation which could have a bearing on the safety of plant personnel and the public in close proximity to the LNG plant."

Respondents contend that this proposed Paragraph 193.109(a)(2) is so vague as to be meaningless, and, therefore, should not be adopted. They assert that it offers no guidance or clues as to what "factors applicable to the particular situation" would require consideration. According to respondents, site selection efforts of prospective terminal operators would in no way be guided by the language of this paragraph.

In our opinion the proposed language is not sufficiently precise and meaningful to serve a useful purpose in promoting safety in the siting of LNG facilities. We will delete the proposed Paragraph 193.109(a)(2) from the adopted regulations.

4. Section 193.111 - Thermal Radiation Requirements

The staff's Section 193.111 requires each impounding area at an LNG facility to be surrounded by a thermal exclusion zone. The proposed requirements for the design of **[*58]** that zone are set forth below:

"The thermal exclusion zone shall be designed so that thermal radiation from the maximum fire in the impounding area does not cause the thermal flux to exceed 1600 Btu/hr-ft<2> at a property line that can be built upon."

The staff recommends that a criterion of 1,600 Btu/hr-ft<2> be used since at this thermal flux persons immediately at the property line would have at least 30 to 40 seconds to retreat from a "worst case" fire, with an added conservative assumption that the wind is pushing the fire in their direction.

Respondents argue that the staff is being inconsistent in requiring thermal radiation buffer zones based on catastrophic failure while permitting some vapor dispersion buffer zones to be based on design accidents of lesser consequence. Respondents' witness Dr. Welker suggested that two levels of fire be considered. He accepted staff's criteria of 1,600 Btu/hr-ft<2> as sufficient protection of the public at a property line against a fire resulting from a "design spill." He contended, however, that the probability of a catastrophic spill is lower, and he suggested use of a 10,000 Btu/hr-ft<2> property line heat flux criteria for such an **[*59]** event.

The staff points out that at 10,000 Btu/hr-ft<2> it would take less than two seconds for a person to suffer second degree burns. The staff believes that the 30 to 40 second period associated with the recommended 1,600 Btu/hr-ft<2> criterion will provide the public with a sufficient level of safety and yet not unreasonably affect land and design requirements.

The staff urges rejection of the 10,000 Btu/hr-ft<2> criterion. The staff points out that, although it is the criterion used in the currently effective 1975 edition of NFPA Standard No. 59A (Item No. O-FF), it is there intended to prevent fire spread offsite rather than to protect directly members of the public.

We are of the opinion that the public safety requires the higher level of protection at the property line as recommended by the staff. The standards adopted herein will apply at any future California LNG site. Future sites, quite conceivably, may have no legislative restrictions on population density. We will adopt the staff's version of Section 193.111.

5. Section 193.113 - Flammable Vapor Requirements

a. Subsection 193.113(a) - Flammable Control Criteria

This subsection, as proposed by the staff, **[*60]** reads:

"Each LNG facility shall be designed to prevent flammable vapor from a design spill as defined in (b) from crossing a property line that may be built upon."

Respondents point out that the words "flammable vapor" could be interpreted to mean any concentration, not just those which when mixed with air are flammable. They recommend this subsection be modified to specifically address vapor which could pose a hazard. Respondents also recommend the subsection be modified to provide that it should minimize the possibility of (rather than prevent) flammable vapor from crossing the plant boundary (rather than property line). Respondents also provide a qualifying clause so that Subsection 193.113(a) would read as follows:

"Each LNG facility shall be designed to minimize the possibility of a mixture of flammable vapor from a design spill as defined in (b) from reaching the plant boundary if the presence of such vapor would present a distinct hazard to life or adjoining property."

We will adopt respondents wording with the addition of the word "potentially" before the word "flammable" and the deletion of the clause "if the presence of such vapor would present a distinct hazard to life **[*61]** or adjoining property."

b. Subsection 193.113(b) - Design Spill Definitions

The proposed subsection giving design spill definitions provides:

"(1) For impounding systems serving components under Section 193.403, flammable vapor control is not required for protected components which are designed to Category I criteria as defined in Section 193.121(a).

"For Category II piping attached to a Category I component, the design spill shall assume failure of the piping under 193.111(b)(2) below.

"(2) For impounding systems serving any components under Section 193.403 which are designed to Category II criteria as defined in Section 193.121(b), the 'design spill' for each component is defined as the largest flow from any single line which could be pumped or flow under the maximum pressure condition encountered during operations. The time duration of the 'design spill' shall be ten minutes or a lesser time period based upon demonstrable surveillance and shutdown provisions acceptable to the Commission."

Respondents point out that the staff's proposed Section 193.113(b) would provide that flammable vapor control is not required for protected components which are designed to Category I criteria. **[*62]** Respondents' recommended

modification would eliminate that exception on the basis that Category I design criteria are related only to structural design requirements and not to vapor dispersion.

Respondents' modification would impose a more stringent and safer requirement. We will adopt their proposed modification for Paragraph 193.113(b)(2) as set forth below:

"For impounding systems serving any components under Section 193.403 the design spill for each component is defined as the largest flow from any single line which could be pumped or flow under the maximum pressure condition encountered during operations. The time duration of the design spill shall be ten minutes or a lesser time period based upon demonstrable surveillance and shutdown provisions acceptable to the Commission."

c. Subsection 193.113(c) - Exclusion Distance

In 193.113(c) the staff has proposed criteria to be used in performing vapor dispersion analyses. These include weather conditions which would provide smaller or equal dispersion distances 90 percent of the time and an average vapor concentration of 2 percent as the criteria for safe dispersal.

(1) Paragraph 193.113(c)(2)

Respondents recommend the **[*63]** modification of the staff's proposed Paragraph 193.113(c)(2), which requires the operator to provide an "exclusion distance" between certain components and the plant boundary so as to mitigate vapor dispersion hazards. The paragraph specifies that in calculating the minimum exclusion distance, the operator must consider the effects of wind conditions at the site. Respondents argue that this would, in effect, require the operator to use the worst-case, which they characterize as an incredible wind condition, to calculate exclusion distance. They contend that this proposed requirement, when read with the 2 percent average vapor concentration requirement at proposed Paragraph 193.111(c)(3) (see below), clearly imposes unrealistic and unwarranted design requirements on the terminal operator.

Dr. Welker, who testified that depending on conditions (relatively stable or unstable) at a given site, it may or may not be prudent for the designer to base his exclusion distance calculations on worst case winds. This witness sponsored respondents' proposed modifications which would require the operators to consider "predominant," rather than "worst case" winds. He testified that consideration **[*64]** of "predominant," conditions would provide the operator with adequate guidance and yet allow the designer to exercise his professional judgment prudently.

It is overly conservative to use the average vapor concentration value for vapor dispersion criteria adopted in Subsection 193.113(c)(3) with "worst case" winds. Therefore, we will adopt respondents recommendation regarding Paragraph 193.113(c)(2).

(2) Paragraph 193.113(c)(3)

This paragraph requires the operator to use an average vapor concentration of 2 percent by volume in air at the property line for the calculation of the exclusion zone. Respondents' expert witness testified that under certain atmospheric conditions (unstable), a terminal operator may want to use lower (i.e., 2 percent) concentrations to determine exclusion distance. He also testified that it would be appropriate for a prudent operator to use a higher (i.e., 5 percent) average concentration in more stable conditions and that the 5 percent average is an adequate minimum requirement for protection of the public.

Respondents recommend that Paragraph 193.113(c)(3) not be adopted; they assert that its deletion would not leave a gap in the regulations. Their **[*65]** witness testified that if the Commission were to adopt Subsection 193.113(a) as proposed by respondents (and as adopted above), it would impose, by implication, a 5 percent concentration requirement.

In order to protect the general public, a facility should be designed so that the concentration of natural gas in the air does not reach a flammable mixture level (5 percent) at the property line. Since LNG vapors generated by a spill disperse by mixing with air, the natural gas composition within air is not uniform. It is evident that an average vapor concentration of less than 5 percent would still have pockets of flammable vapor at the property line. We consider pockets of flammable vapor at the property line to be unacceptable.

The staff has proposed a 2.0 percent vapor concentration at the property line. However, the staff witness, Dr. Drake, testified that vapor dispersion models are based on average vapor concentration. This corresponds to a vapor concentration of 2.5 percent. Accordingly, we will require LNG operators to compute plant boundaries by using a

natural gas vapor concentration of not more than 2.5 percent in air for computing the exclusion criteria. The adopted **[*66]** language for Paragraph 193.113(c)(3) will be:

"An average vapor concentration of not more than 2.5 percent by volume in air shall be used as the criteria for computing the exclusion distance."

d. Subsection 119.113(d) - Planned Ignition

In this subsection the staff provides design requirements for planned ignition if the operator elects to install such a system. The staff contends that planned ignition could be used to mitigate dispersion hazards if the plant property were not sufficiently extensive to meet the exclusion distance criteria. In Section 193.111 the staff recommends a substantial thermal radiation buffer zone for LNG impoundments based on a property line heat flux of 1,600 Btu/hr-ft<2>. Only a very serious LNG vapor dispersion accident could create flammable vapor with a potential for traveling a distance equal to or greater than the separation distance defined in Section 193.111. In its opening brief the staff argues:

". . . Thus, planned ignition of flammable vapors at a property line affords protection to the public offsite. A minor accident would be unlikely to create such a major vapor dispersion hazard and thus vapor from minor spills would be dispersed **[*67]** before reaching the igniters near the property line."

The staff points out that the utilities are suggesting use of a smaller thermal radiation buffer zone based on 10,000 Btu/hr-ft<2> criteria. The staff is proposing a much greater buffer zone, contending planned ignition near a property line would, therefore, be unlikely to ignite a small spill. According to the staff, small spills would be dispersed before reaching the igniter and only major spills could create explosive concentrations of vapor at the igniter.

Respondents state that, while they recognize that Section 193.113(d) is permissive, they urge in the interest of public safety that it not be adopted. They contend that use of planned ignition to mitigate vapor dispersion is contrary to existing practice and, in fact, could exacerbate, rather than mitigate, a potentially hazardous condition.

The record herein does not provide us with sufficient assurance that planned ignition is, in fact, a means of hazard reduction. We will, therefore, not adopt proposed Subsection 193.113(d).

6. Section 193.115 - Geologic and Seismic Siting Criteria

The following discussion of geologic and seismic siting criteria under this section **[*68]** is interrelated to the preceding discussion of the definitions of faults under Section 193.5.

a. Subsection 193.115(b) - Scope

In Subpart B and again in Appendix B, the staff has proposed a sentence which requires that sufficient geological data be obtained to assure that an LNG facility can be constructed and operated at a site without "recognizable" risk. Respondents request that the word "recognizable" be deleted and the word "undue" be substituted. They point out that, if the staff proposal is interpreted literally, it would require that no risk to the health and safety of the public may result from the construction and operation of an LNG terminal. Respondents, while conceding that the word "undue" is not a precise word, urge that it be substituted for "recognizable."

We agree with respondents that "nothing can be done without any risk." We will adopt respondents' recommendation. We will make the substitution so as to convey the concept that the facility is to be constructed and operated without producing an unacceptable hazard. The Commission will, as appropriate, determine what constitutes an "undue" level of risk.

Respondents also recommend that the words, ". **[*69]** . . site suitability and if the site is suitable to determine . . ." be deleted from this subsection and that the following wording be added as the first sentence of the next paragraph, "These criteria, which apply to LNG facilities, describe the nature of the investigations required to obtain geologic/seismic data necessary to provide reasonable assurance that LNG facilities can be constructed and operated at a site without posing an undue hazard to public health and safety."

We will adopt these suggested changes of wording. They will make Subsection 193.115(b) consistent with our holding in the discussion of Section 193.5, where we stated that site suitability is not to be made solely on the basis of geologic investigation, but rather it is to be made on an overall evaluation also involving engineering and economic feasibility.

b. Subsection 193.115(f) - Seismic Design Criteria

As we decided in the discussion above (under Section 193.5), the evidence will not support the staff's proposal in this subsection that a potential LNG site containing a causative fault be excluded from further consideration.

The staff has also proposed in this subsection that no LNG tanks or critical **[*70]** components be sited within 100 feet of a secondary fault. Although the term "secondary fault" was deleted from these standards in our discussion under Section 193.5, the issue of setback criteria from faults remains and will be discussed below.

The record before us indicates that highly respected structural engineers believe they can design to accommodate significant surface rupture. The staff's Dr. Young and Mr. Degenkolb of the CCC stated, however, that such design should be undertaken only if no other alternatives are available. The record shows that such design would of necessity be special and significantly more costly. The record also clearly indicates that the actual location of a ground rupture within a fault zone cannot be precisely predicted. We are not sufficiently convinced, however, that structural engineers can design for the surface rupture associated with even relatively small faults with the degree of reliability demanded by public safety.

We are impressed also with the fact that, although various structures with a complexity and inherent risk similar to an LNG facility have been designed to withstand fault displacement up to a few feet, none have actually been **[*71]** subjected to such displacement. Apparently, therefore, no such facility has actually been tested and survived the degree of ground rupture that is the concern of Subsection 193.115(f).

The respondent's proposal contemplated that a complete review of geological and engineering data be made prior to deciding whether it would be appropriate to design for surface rupture or to set back from a fault with a potential for surface displacement. Assuming the latter were indicated, the amount of setback would be determined on a case-by-case basis because of the variable rupture characteristics of different structures to surface fault displacements.

We agree that a complete review of geological and engineering data is a prerequisite to determination of an appropriate setback distance. We believe, however, that the evidence discussed above regarding the difficulty of designing for significant displacement, the uncertainity as to where ground rupture may actually occur, and the fact that no critical structure similar in complexity and risk to an LNG facility has ever actually withstood ground displacement dictates the requirement for a 100-foot setback similar to that proposed by the staff. **[*72]** To allow a facility operator to attempt to design to accommodate surface displacement would be to incorporate into these standards a level of risk that is simply unacceptable given our duty to foster public safety.

We are of the opinion that a minimum set back of 100 feet from a capable fault be required. We will, therefore, modify Subsection 193.115(f) to adopt the changes proposed by respondents for Subsection 193.115(f) with the following addition:

In no case may an LNG tank be sited within 100 feet of a capable fault.

7. Section 193.117 - Geotechnical Investigations For Foundations

The staff's proposed Paragraph 193.117(a)(4) provides that geotechnical facilities shall include information needed to define:

"Geotechnical parameters needed for analysis and design of plant area fills, structural fills, back fills, and dikes. The scope of the geotechnical investigation will vary according to the complexity of: topography, geology and geotechnical conditions at the LNG site. The operator shall conduct the investigation in sufficient detail, using most recent and generally acceptable techniques and procedures, so as to establish the geotechnical conditions at or near the site **[*73]** with reasonable accuracy. Regulatory Guide 1.132 of the Nuclear Regulatory Commission should be used as baseline procedures. In addition, the geotechnical investigation shall satisfy the requirements of Section 193.115."

Respondents urge deletion of the sentence, "Regulatory Guide 1.132 should be used as baseline procedures. n10 Their soils engineering expert, Mr. Jack Yaghoubian, explained in some detail why NRC guidelines are inapplicable to soils investigations required for an LNG facility. He also explained the differing approach of soils engineers to soil boring programs, depending on whether soils are uniform or nonuniform in character.

n10 As defined in Section 193.5,

"'Baseline relationships or procedures' are relationships or procedures that are to be used as guidelines and are not to be interpreted to be required procedures. Recommendations should be based on site specific

assessments of regional and local conditions as well as consideration of the baseline relationships or procedures."

Respondents point out that the proposed safety regulation in Section 193.115(h) (which is not being contested by respondents) specifically require that the geotechnic documents be **[*74]** prepared under the direction of a licensed civil engineer. Geologic reports will be required to include the name, license number, and certification number of the individual supervising report preparation. The staff has presumably included such professional requirements in the safety regulations to assure that no unqualified individuals will undertake the geotechnic investigations.

The staff takes the position that the nature and scope of soils investigations required for an LNG facility depends on the type of structures and their foundations, settlement criteria, type and nature of the soils and geotechnical conditions present at the site. Regulatory Guide 1.132 is a comprehensive document covering all the procedures that can be used for a broad range of structures including structures for LNG facilities.

We are of the opinion that the provisions of Regulatory Guide 1.132 are appropriate because the guidelines are comprehensive, and will provide definite procedures to be used in monitoring activities. We will, therefore, adopt staff's recommendation regarding Section 193.117.

8. Section 193.119 - Earthquake Vibratory Ground Motion Criteria

Paragraph 193.119(2)(iii). of this **[*75]** section specifies that the horizontal response spectra amplification factors and spectral shapes are defined in a table of amplification factors and a graph of baseline horizontal response spectra (Figure B-1), scaled to the applicable design maximum accelerations. These are intended to be used as a baseline when defining the SSE n11 and OBE n12 horizontal elastic design response spectra. There is no disagreement between staff and respondents on the language of this subsection. Respondents, however, propose to delete the staff's amplification factors table and Figure B-1 and substitute therefor Newmark and Hall response spectra.

n11 As defined in Section 193.5,

"The 'Safe Shutdown Earthquake; (SSE) shall be characterized by the earthquake(s) which will produce the greatest ground shaking at the site and shall be based on an evaluation of the maximum earthquake(s) that can be postulated to be capable of occurring under the presently known tectonic framework. It shall be a rational and believable event that is in accord with all known geologic and seismic data."

n12 As defined in Section 193.5,

"An 'Operating Basis Earthquake' (OBE) shall be characterized by the maximum earthquake vibratory ground motion which it is advisable to design the LNG plant to withstand without loss of operational function." **[*76]**

The response spectra recommended in the staff's Figure B-1, as baseline horizontal response spectra and the amplification factors in the accompanying amplification table have the shapes and amplification factors recommended in Regulatory Guide 1.60 of the NRC. The staff asserts that these spectra are widely used and that a recent and extensive correlation of response spectra by Werner and Ts'ao (1977) has confirmed that the shapes and the amplification factors given in Regulatory Guide 1.60 (and in Figure B-1) are correct. The staff does not agree to the use of the Newmark and Hall spectra as baseline spectra. The staff states that the spectra they recommend are better known to the engineering profession and have a more correct shape. The staff further states that the amplification factors given by Newmark and Hall are smaller than the Figure B-1 factors, e.g., the acceleration amplification factor for 0.5 percent damping at 2.5 Hertz (Hz) is 5.10 as proposed by respondents, as contrasted with 5.95 as proposed by the staff.

The staff points out the Commission in Decision No. 89177, Condition 40, adopted the following:

"Regulatory Guide 1.60 response spectra, properly scale to **[*77]** the peak ground accelerations recommended for the SSE and OBE shall be used in the design of Category I and II structures, components and systems."

The base line horizontal response spectra found in Figure B-1 were developed by the NRC in the early 1970's. Respondents recommend that an updated version of that response spectra, formulated by Drs. Newmark and Hall and presented in a 1976 paper entitled "Earthquake Resistant Design of Nuclear Power Plants" (Exhibit No. 0-152) be adopted in lieu of the response spectra found in Regulatory Guide 1.60 n13 Dr. Newmark stated that he has performed several new studies both before and following the development of Regulatory Guide 1.60 on the characteristics of

design response spectra. He testified that, based upon these studies, he developed the revised response spectra recommended in these proceedings by him and by the respondents. These revised response spectra, in Dr. Newmark's opinion, are "better, more rational, and more consistent" than the response spectra found in Regulatory Guide 1.60. Dr. Newmark pointed out that although the NRC has not yet modified Regulatory Guide 1.60, it has, on a case-by-case basis, accepted his recommendations **[*78]** that deviations from that guide be utilized. Dr. Newmark recommended that the updated response spectra be utilized in this Commission's safety regulations.

n13 Dr. Newmark was one of the authors of Regulatory Guide 1.60 response spectra.

The staff suggests that the Newmark and Hall (1976) spectra are less conservative than the Regulatory Guide 1.60 spectra. Respondents counter that, although as illustrated by the staff, the Newmark and Hall (1976) response spectra are slightly less conservative than the Regulatory Guide 1.60 reponse spectra at 2.5 Hz, it is important for this Commission to recognize that the spectra in question are more or less conservative relative to each other at different frequencies. At the particular frequency ranges of interest for an LNG terminal at the Point Conception site, the Newmark and Hall (1976) spectra are more conservative than the Regulatory Guide 1.60 spectra. The record shows that fundamental LNG tank frequency mode is in the 10 Hz range. In the 10 Hz frequency range, the Newmark and Hall (1976) spectra are 3 percent greater than the Regulatory Guide 1.60 spectra. The fundamental frequency of the dock and trestle is in the 1 Hz range. **[*79]** In the 1 Hz frequency range, the Newmark and Hall (1976) spectra are 16 percent greater than the Regulatory Guide 1.60 spectra. Hence, the staff's suggestion that the Newmark and Hall (1976) response spectra are less conservative than are the Regulatory Guide 1.60 spectra does not appear to be valid at certain frequencies.

It is evident that there are insignificant differences between the Newmark and Hall (1976) spectra and Regulatory Guide 1.60 spectra. We will, therefore, adopt both Regulatory Guide 1.60 and Newmark and Hall (1976) spectra as acceptable response spectra.

In its opening brief, the CCC proposes that the following requirement be added to Paragraph 193.119(2)(iii):

"However, the static horizontal force used for purposes of elastic design shall never be less than 15% of the weight of the structure, or such other level determined by the interdisciplinary review board established by this Order."

This recommendation overlooks the fact that equivalent static load design methods, common to building code design, are not permitted in the proposed safety standards for Categories I and II items. Since a dynamic analysis is required for these items, an adequate force will be **[*80]** determined by the analysis. Therefore, this requirement is not needed.

9. Section 193.123 - Seismic Design Analysis And Testing Methods

Respondents recommend that damping values different than those proposed by the staff be adopted. The staff objects to the damping recommended by respondents for two basic reasons: (1) some values recommended by the utilities are not all-inclusive but apply only to the type of tank proposed by Western Terminal for Point Conception; and (2) the damping specified by the staff is based on NRC Regulatory Guide 1.61 which should be used to be consistent with the use of NRC Regulatory Guide 1.60 horizontal response spectra.

Respondents concur that their proposed modifications to the staff's Table B-1 14 do not apply to all LNG tanks but only to the type of tank contemplated for the Point Conception facility. Respondents propose in their reply brief to answer the objection voiced by the staff by inserting the term "(Above-Ground Double Walled Steel)" in their version of Table B-1.

n14 Table B-1 presents damping values as a percent of critical damping, as adopted by the staff from NRC Regulatory Guide 1.61.

The staff states that the larger damping **[*81]** values proposed by respondents would result in small design forces. They contend that respondents' proposal is, therefore, not sufficiently conservative. Repondents counter that there is no evidence in the record which supports this position and points to the following footnote to their version of Table B-1, a quote from Exhibit No. 0-152:

"The lower level of the pair of values given for each item are considered to be nearly lower bounds and are therefore highly conservative; the upper levels are considered to be average or slightly above-average values and

probably are the values that should be used in design when moderately conservative estimates are made of the other parameters entering into the design criteria."

We note that respondents' version of Table B-1 provides for ranges of damping values for the majority of listed structures and components in contrast to the staff's version which gives a single damping value of each tabulated peak stress. Dr. Newmark, the author of respondents' version, explained:

"I have given a range of damping value in this paper, Reference (c), to clarify the fact that damping should be a level of the response rather than a firm or fixed value. **[*82]**

"Because I felt that Regulatory Guide 1.61 has often been misinterpreted by the people using it and this is intended to give better guidance.

"Damping is something that is difficult to determine precisely."

We agree with the statement made by Dr. Newmark that damping is difficult to determine precisely. In addition, the differences in damping values, between Regulatory Guide 1.61 and Dr. Newmark's proposal, are small. We will adopt Regulatory Guide 1.61 and respondent's recommended damping values for one-half of the yield stress and the lower values for yield stress. This is consistent with our adoption of Regulatory Guide 1.60 and Dr. Newmark's response spectra. However, to be consistent, Regulatory Guide 1.60 response spectra should be used with Regulatory Guide 1.61 damping values, and Dr. Newmark's response spectra and damping values should be used together.

In its opening brief, the CCC staff proposes that a new paragraph entitled "Out-of-Phase Ground motion Effects," be added to Subsection 193.123(a) as follows:

"The effects of out-of-phase ground motions upon all large structures, including LNG storage tanks, trestles and cryogenic pipelines in the assumed SSE and OBE shall **[*83]** be calculated."

They further recommend that the following requirement be added to Section 193.517 - Foundation:

"A continuously tied foundation mat shall be used unless an alternative configuration can be shown to provide equal or superior performance."

The CCC staff argues that the above two amendments are necessary because they would require greater consideration of the effects of out-of-phase ground motion. The CCC staff contends that the proposed safety order only makes passing reference to this problem and that, in so doing, fails to give it the attention it deserves.

The Commission recognized this problem in Decision No. 89177 in its Condition 38 - Storage Tank Foundation which reads:

"Western Terminal is directed to place a reinforced concrete mat under the LNG storage tanks, unless a careful analysis demonstrates conclusively that it is not needed and is approved by the Commission."

Condition 38 differs significantly from the recommendation of the CCC staff insofar as it requires a reinforced concrete mat unless it can be demonstrated that a mat is not needed. The CCC staff recommendation would require that such a mat be utilized unless it was demonstrated that a different **[*84]** configuration will provide equal or superior performance. The CCC staff's proposed additions do not recognize that at some sites conditions may exist which do not warrant the installation of a continuously tied foundation mat; hence, they do not provide the design flexibility which the evidence in this case has shown to be appropriate. Accordingly, we will not adopt the two proposed additions.

The CCC staff also recommends that the following paragraph, entitled Differential Fault Movement, be added to Subsection 193.123(a):

"The terminal shall be designed to withstand differential fault movement of several inches to a few feet at any point beneath all Category I structures and cryogenic transfer lines."

In Section 193.115(f) we require a thorough seismic investigation to identify capable faults and further provide a minimum setback from such faults. It is unreasonable to require the design for unknown differential displacement as well. We will not adopt this proposal.

10. Section 193.133 - Design for External Manmade Hazards

As proposed by the staff, this section provides as follows:

"Each operator shall determine from historical records and from engineering analyses the **[*85]** risks associated with external man-made hazards. Such hazards shall include, but not be limited to, the impact on facility structures, components, and systems by aircraft, missiles, or missile fragments; explosions of surface vehicles; failure of dams or other distant structures which could affect the site, and explosions or accidents of pipeline systems, or other adjacent chemical storage systems, process systems, or power generating facilities. Unless analyses show that the exclusion criteria of this subpart is satisfied, the Operator shall include the possible effects of these hazards in the design."

This section is substantively redundant of Section 193.105. No purpose would be served in this rulemaking by adopting proposed Section 193.133.

11. Section 193.135 - Load Combinations, Load Factors, Allowable Stresses, and Ductility Factors for Design

Respondents propose changes in four significant areas of the staff's recommended Section 193.135. These changes would: (a) permit the reduction of elastic response spectra by the use of ductility factors n15 for Categories I and II structures; (b) provide for higher allowable stresses for Category I items for SSE and Safe Shutdown **[*86]** Wind Loads (SSW) n16 ; (c) permit lower load factors for Categories I and II items for SSE or SSW; and (d) introduce special provisions for the design of berms and dikes.

n15 "Elasticity is the ability of a structure to deform and return to its original shape upon removal of the load. "Ductility" is the ability of a structure to deform permanently (or "inelastically") without functional impairment. "Ductility factor" is a measure of the inelastic deformations that a structure can acceptably tolerate.

n16 Subsection 193.125(b) - Wind Loads states, "The wind speed for SSW computations shall be established deterministically as the maximum value that can reasonably be expected to occur at the LNG site. It shall be taken as 160 mph unless a lower value can be justified."

a. Ductility Factors

Subsection 193.135(c), as proposed by the staff, would require that all Category I structures, components and systems behave elastically at the safe shutdown earthquake (SSE) level. Elastic behavior, as used here, is the ability of a structure to survive a design force, in this case an SSE, without any permanent deformation. All Category II structures, components and systems would be required **[*87]** to behave elastically at the operating basis earthquake (OBE) level, but would behave inelastically (i.e., suffer some structural damage and permanent deformation) at the SSE level. Category III items would be designed to behave elastically at earthquake levels specified by the Uniform Building Code but would suffer structural damage at both the OBE and SSE levels.

The respondents disagree with the staff's recommendations for Category I and Category II items. They contend that some structural damage (i.e., permanent deformation) should be permitted for both the Category I items at the SSE level and Category II items at the OBE level. This would be accomplished by the respondents through the introduction of ductility factors. The respondents propose a ductility factor of up to 1.3 for Category I items at the SSE level and a ductility factor of up to 3 for Category II items at the SSE level. On this basis, the respondents would provide for elastic behavior based on dynamic forces approximately 20% lower than proposed by the staff for Category I items at the SSE level and for elastic behavior for Category II items at the OBE level based on dynamic forces approximately 40 to 50% **[*88]** lower than proposed by the staff.

We consider the question of whether to incorporate the use of ductility factors into these safety regulations to be one of the most important safety issues before us. The record demonstrates, and common sense suggests, that a certain level of reserve strength should be built into the design of LNG facilities. This reserve strength is necessary to prudently provide for the inevitable uncertainties inherent in seismic analysis, design and construction.

The staff objects to the introduction of ductility factors into LNG plant design. They assert that, "Introducing ductility factors into the design procedure represents an adjustment to the reserve strength of Category I and II structures, components and systems at strain levels above the limit of elastic behavior." In order to maintain an adequate level of reserve strength for critical structures, the staff argues that it is essential that those structures be designed to behave elastically during a design earthquake event.

The respondents counter these arguments by asserting that there is no evidence that Category I and Category II items must remain elastic during the specified seismic design events. **[*89]** They further state that the definition of

Category I structures, components and systems states that these items "must be able to perform their safety related function without repair during and following the SSE," and that this does not require elastic design.

If we were to adopt the respondents' proposal we would, in effect, be allowing the potential for plastic deformation of a structure or component at the specified seismic design event. The record indicates that the degree and extent of deformation that would actually occur cannot be precisely predicted beforehand. By adopting the proposed ductility factors, we would be reducing that margin of uncertainty that we referred to above as a level of reserve strength and reducing it by an unknown amount. The record indicates that some structures have been designed to behave inelastically during the design earthquake event. None of these structures, however, has experienced a seismic acceleration which could provide evidence to demonstrate the behavior of those structures under actual seismic design conditions.

The basic difference, then, between the staff's and the respondents' recommendations is the level of conservatism to be **[*90]** incorporated into the design. We are not sufficiently convinced that the respondents' proposal would ensure that critical structures would remain in a safe condition during and following the design earthquake events. In light of the great risk to public safety associated with the failure of a critical component such as an LNG tank, we must adopt the more conservative design approach proposed by the staff.

The staff further points out that adoption of ductility factors in this phase of these combined proceedings would serve to counteract our order in Condition 41 of Decision No. 89177. We ordered there that Western Terminal use an acceleration of 0.7g as the design acceleration for all critical components at the proposed LNG facility at Little Cojo. The record indicates that application of ductility factors would reduce the imposed seismic dynamic forces for the structures being designed. In the case of our Condition 41 requirement, applying a ductility factor of 1.3 to the design acceleration of 0.7g would result in a design acceleration of only 0.55g. This lower design acceleration would clearly not meet the level of safety we intended to require in Condition 41 of Decision **[*91]** No. 89177.

The record before us demonstrates that the inclusion of ductility factors greater than unity is undesirable. It would allow an unacceptable erosion of that margin of reserve strength that would be incorporated in the seismic design under the staff's proposal.

Inclusion of ductility factors would also contradict the intent of our previous order in Decision No. 89177. The respondents' proposal is therefore rejected. The staff's proposal requiring elastic design for critical structures, components and systems will provide a reserve strength that will better assure that these items will remain in a safe condition in the event of a design earthquake. We therefore adopt the staff's proposed Subsection 193.135(c).

b. Allowable Stessess

Subparagraph 193.135(c)(1)iii, as proposed by the staff, provides as follows:

"In addition, for Category I structures, components, and systems subject to normal operating loads plus Safe Shutdown Earthquake (SSE) or wind (or tornado) (SSW) loads, the code allowable stresses may be increased by 50 percent (but not to exceed 90 percent of the minimum yield stress level) for ductile elements, over that permitted for normal operating loads **[*92]** only."

Respondents recommend that the allowable stresses be increased from 50 to 67 percent and that the limit of 90 percent of the minimum yield stress level be increased to the minimum yield stress level. We will accept staff's recommendation which is consistent with our determination, supra, adopting staff's recommendations on elastic design.

c. Load Equations

In Paragraph 193.135(c)(2), the staff proposes to use the load factors indicated in the equation below when combining SSE or SSW loads with dead and live loads for Category I equipment. n17

U = 1.05D + 1.1L + 1.0E' (or 1.0W')

n17 Where D is dead load, L is live load, E' is safe shutdown earthquake load, W' is safe shutdown wind or tornado load, and U is the required total element load.

Respondents recommend that unity load factors be used in each term of the above equation.

The staff in its Exhibit No. 0-142 explains that environmental loads such as safe shutdown earthquake (E') or safe shutdown wind (W') have very low annual probability of occurrence (yearly exceedance of 10<-4>). A load factor of unity is recommended for those extreme environmental loads. In contrast, the dead (D) and live (L) loads are nominal **[*93]** loads and have a likely probability of occasionally being exceeded. There are also uncertainties in the design analysis procedures, construction deviation, and material behavior. The staff, therefore, recommends that load factors be slightly more than unity for the live and dead loads.

We agree with the staff that the load factors for live and dead loads should be greater than unity. We will adopt staff's recommendation for the above load equation.

d. Deformation of Berms and Dikes

Respondents propose that a new Paragraph 193.135(c)(5), entitled "Berms and Dikes", be added as follows:

"Berms and Dikes classified as Category I or II are permitted to deform but such deformation must be limited to values that would not permit overtopping or leakage through them."

The staff recommends that this paragraph not be added for the following two reasons:

1. Section 193.121 provides the general seismic performance requirements for all Category I and II structures, components, and systems; hence, there is no logic in selecting a specific structure, component, or system for special comment, particularly when the comment is a general statement adequately covered in Section 193.121.

2. **[*94]** Section 193.135 is restricted to load combinations, load factors, and allowable stresses and the proposed statement on berms and dikes makes no reference to these items; hence, it is inconsistent with the subject matter considered in Section 193.135.

We agree with the staff position, and, therefore, we will not adopt respondents proposed paragraph on berms and dikes.

e. CCC's Recommendation

The CCC recommends that the following be added to the safety regulations as Subsection 193.135(3) - "Non-Catastrophic Failure":

"The Operator shall demonstrate to the satisfaction of the interdisciplinary review panel that design features, materials and details have been selected to provide the maximum achievable ductility in all Category I structures, and to insure that in the event of greater than anticipated environmental loads, failure will be gradual rather than catastrophic."

In furthering its recommendation of achieving "maximum achievable ductility", the CCC staff urged, during its participation in the hearings, that stainless steel, rather than 9 percent nickel steel as proposed by Western Terminal be used for the LNG storage tanks.

The record shows that the performance of 9 percent **[*95]** nickel steel is acceptable for utilization in the construction of LNG storage tanks. There is no basis for us to conclude that significant safety benefits would be achieved by utilizing the considerably more costly stainless steel. It will not be necessary to adopt proposed Subsection 193.135(e) because the safety standards adopted herein will otherwise provide for adequate ductility.

The proposed requirement to provide the maximum achievable ductility is indefinite and open ended. As the staff states in its closing brief, "For example, one could conclude that the maximum achievable ductility could be achieved only by using the most ductile metal available, which is gold. While gold has superb ductility, it is not a satisfactory structural material for LNG facilities."

12.Section 193.139 - Separation of Components

As set forth below, this proposed section would impose certain spacing requirements between the various components of a facility and between those components and the plant boundary:

"Each LNG facility site must be large enough to provide for minimum separations between critical components and between components and the site boundary to--

"(a) Permit predictable **[*96]** movement of personnel, maintenance equipment, and emergency equipment within the facility, and

"(b) Minimize spill and collapse hazards to persons and property on and off the site, unless protection comparable to separation is provided.

"(c) Separation distances between critical components and critical systems shall not be less than the separation distances specified in Section 213 through 216 of Chapter 2 of NFPA 59A."

The purpose of this proposed section is to require the operator to place components on a site so as to allow sufficient space surrounding the component to: (1) permit movement of people and equipment, and (2) minimize spill and collapse hazards to people and property on and off the site.

In the section's first sentence respodents propose deletion of the words "between critical components and between components and the site boundary." The staff witness on this section testified that this section is intended to apply to all components, critical or noncritical. The staff urges that this intent be preserved in the adopted version. In its opening brief the staff concedes that the deletion proposed by respondents would accomplish this intent. Accordingly, we will make **[*97]** the proposed deletion in the adopted version.

Respondents propose that Subsection 193.139(b) be revised to read: "Meet the thermal radiation and vapor limitations as defined in Sections 193.111 and 193.113. The staff states that this proposal is contrary to its specific intent, i.e., to protect persons and property onsite as well as offsite." The staff contends that respondents' proposed Subsection 193.139(b) would not provide onsite protection and, therefore, it should be rejected. The staff asserts that the purpose of Section 193.111, "Thermal radiation requirements", and Section 193.113, "Flammable vapor control requirements", is offsite protection of people and property and that respondents proposal would not provide protection for the operator's employees and property.

Respondents point out that the staff would impose the requirements of Sections 193.111 and 193.113 so as to protect persons within the facility boundary to the same degree as members of the public outside the boundary. Respondents avouch that they share the staff's concern for plant personnel. They maintain, however, that to require separation distances within the plant which would protect onsite personnel to **[*98]** the same degree as offsite personnel "is patently unrealistic and could impose enormous land costs upon the terminal operator".

Our review of the record fails to disclose any suggestion that onsite personnel would be subjected to unreasonable risks absent these requirements. The regulations adopted herein will require terminal operators to provide all plant personnel extensive training and protective equipment to enable them to cope with emergency situations. For these reasons and to avoid imposing unnecessary land requirements on terminal operators, we will adopt the following text for this subsection:

"(b) Meet the thermal radiation and vapor dispersion limitations as defined in 193.111 and 193.113."

D. Part III, Subpart D - Buildings and Components

1. Section 193.319 - Piping, General

At Subsection 193.319(g), the staff has proposed the following:

"To the extent practical, seamless pipe should be used for process and transfer piping handling LNG or other flammable refrigerants."

The record before us indicates that use of seamless pipe would be preferable to welded seam pipe for reasons of reliability as well as economy. Welded areas of longitudinally welded pipe **[*99]** undergo thermal stresses in the welded areas during the welding process. These stresses may ultimately lessen the pipe strength after the cooling process. In seamless piping, on the other hand, no such heat stresses develop and this results in a somewhat more reliable pipe. The record also indicates that seamless piping will be less expensive than longitudinally welded piping.

Because the use of seamless piping will contribute to LNG facility safety and economy, we will adopt the staff's proposed Subsection 193.319(g). That proposal requires the use of seamless piping "to the extent practical." In adopting this proposed language, we deem "to the extent practical" to mean that an LNG facility operator may use longitudinally welded pipe when seamless pipe or seamless fittings are not available at the time required by the facility construction schedule. In addition, longitudinally welded piping may be used in those pipe sizes for which seamless piping is never available.

2. Section 193.323 - Electrical Systems

Section 193.323(b), as proposed by the staff, provides as follows:

"Fixed electrical equipment and wiring shall be installed in accordance with Table 7-1 of NFPA 59A, **[*100]** except that Division 1 shall be used for all services where either Division 1 or Division 2 is permitted in an LNG container area."

NFPA 59A incorporated by reference NFPA 70, the National Electrical Code, n18 which in turn defines certain electrical wiring design requirements. Those requirements are somewhat more conservative for wiring in Division 1 than Division 2 locations. The different design requirements are based on the extent to which the wiring will be exposed to flammable gas. In NFPA 70 "Division 1", as used here, is described as follows:

"A Class I, Division 1 location is a location: (1) in which hazardous concentrations of flammable gases or vapors exist continuously, intermittently, or periodically under normal operating conditions; or (2) in which hazardous concentrations of such gases or vapors may exist frequently because of repair or maintenance operations or because of leakage; or (3) in which breakdown or faulty operation of equipment or processes might release hazardous concentrations of flammable gases or vapors, and might also cause simultaneous failure of electrical equipment."

n18 NFPA 70 is included in this record by reference as Item O-GG.

It is the **[*101]** staff's interpretation of the foregoing definition that the entire LNG container area should be considered a Division 1 area. According to the staff this would result in higher safety and reliability of the electrical equipment in the LNG container area because Division 1 wiring requires explosion-proof enclosure of electrical devices. Respondents argue that placement of the explosion-proof enclosures on wiring at "Division 2 locations" would not enhance safety as moisture may enter the enclosures and cause them to malfunction.

It is evident that the use of Division 1 wiring may increase the level of safety when the installation is new. However, this will create maintenance problems because moisture entering into the electrical enclosures may result in a less safe condition, especially when the installation has been in service for a period of time. Therefore, we will adopt the respondents' recommendation for Subsection 193.323(b).

E. Part III, Subpart E - Impoundment; Design and Capacity

1. Section 193.403 - Impoundment Systems

The staff has made the following proposal for Section 193.403:

"(a) An impounding space shall be provided for:

"(1) LNG and flammable liquid **[*102]** refrigerant storage tanks per Section 193.427; and

"(2) Transfer systems to the extent practical.

"(b) An impounding system shall be provided for the following components and areas to handle and/or contain spills of LNG or flammable refrigerants:

"(1) Process equipment containing LNG or flammable liquid refrigerants;

"(2) Vaporization equipment; and

"(3) Parking areas for tank cars or tank trucks containing LNG."

Subsections (a) and (b), above, provide that certain LNG facilities must have impounding spaces while others are required to have only impounding systems. Section 193.5, Definitions, draws the distinction that an impounding space must be designed to contain spilled liquid whereas and impounding system need control only the course of the spill. To illustrate that distinction, properly designed drainage and grading could serve as an impoundment system but not as an impounding space.

Subsection 193.403(a) requires the operator to provide an impounding space for transfer system "to the extent practical." It is respondents' position that requiring impounding spaces for all transfer systems, even "to the extent practical," is an unreasonable and unjustified requirement. They **[*103]** point out that transfer systems would include all LNG transfer piping at an LNG facility, presumably even that on the dock over water. They contend that the record demonstrates that the likelihood of a spill occurring on transfer piping would be considerably less than at other LNG

facility components and that, furthermore, it would be impractical for a terminal operator to provide an impounding space or system for transfer piping, given the length of such piping present at LNG facilities.

Respondents state that they recognize that there are certain points within the transfer system when mechanical connections occur which should have an impounding system because it is at the point of such connections that spills would be most likely to occur. Respondents contend that these points are included within the term "cargo transfer system," as that phrase is defined and used in these proposed regulations. They urge that Section 193.403 be adopted with the following modifications:

(1) Paragraph (a)(2), which would require impounding spaces for transfer systems, should be deleted, and

(2) A paragraph should be added to Subsection (b) to require impounding systems for cargo transfer systems. **[*104]**

On the other hand, the staff is urging that impounding spaces be provided for all transfer systems to the extent practical. They point out that under respondents' proposal fluid spilled from cargo transfer systems would be allowed to flow away from the spill area by means of the grading and drainage of an impounding system. The staff proposes a stricter requirement in that spills from all transfer systems, not just cargo transfer systems, would be confined in an impounding space which is defined as a volume of space formed by dikes and floors. We are of the opinion that impoundment is needed for all transfer systems including cargo transfer systems and other flammable fluid and flammable refrigerant transfer systems. Spillage from all transfer systems has the potential of not only resulting in fire or vapor dispersion in the transfer area but also of causing damage to components which are contacted by cryogenic liquids. The possibility of accident as well as sabotage exists for all transfer systems. Positive means must be provided to assure that, to the extent practical, spilled liquid from any transfer system does not reach waterways or cause failure of other components.

We **[*105]** will adopt Section 193.403 as proposed by the staff.

2. Section 193.405 - General Design Requirements

This section would impose general design requirements for impounding systems. Staff proposed Subsection 193.405(a) reads:

"An impounding system shall have a configuration or design which will prevent LNG or flammable liquid refrigerant from escaping the impoundment under the worst spill conditions."

Respondents have repeatedly asserted throughout these proceedings that "Staff's proposed regulations contain numerous instances in which their requirements are premised on extreme, incredible scenarios or possibilities." They cite the proposed Section 193.405 as "just one more example of that extremism." Respondents contend "that these regulations ought not to, by assuming one extreme, incredible event after another, impose unreasonable and unjustified design requirements on LNG facilities." It is respondents' position "that imposing the requirement that terminal operators must design impounding systems for the undefined worst spill condition is totally unreasonable and unjustified." Accordingly, respondents urge that Section 193.403 be adopted with their recommended modifications **[*106]** which would "require that impounding systems be designed for the design spill, not the incredible worst spill conditions." (See Appendix B.)

The staff believes it prudent and necessary that impoundment systems be designed to handle the worst potential spill of LNG or flammable liquid refrigerant. A lesser requirement would provide insufficient protection to the public and plant personnel. An example of a "worst spill" would be the simultaneous failure of two or more of the fill or withdrawal lines. Respondents propose to design impoundment systems to a less stringent requirement. They would design impoundment systems to handle the largest flow from only a single line. Under the respondents proposed wording, which follows below, the "worst spill for one single line" would be the same as the design spill as defined in Subsection 193.113(b):

"The largest flow from any single line which could flow or be pumped under maximum pressure condition encountered during operations from escaping the impoundment."

We are of the opinion that if there is a possibility of more than one pipe failing, this potential hazard should be taken into account in designing the impounding system. There is **[*107]** nothing in this record which assures us such a spill could not occur. We will adopt the staff's proposal in the interest of the public's safety.

3. Section 193.427 - Impoundment Capacity; Storage Tanks

Subsection 193.427(a), as proposed by the staff, would provide as follows:

"Each LNG storage tank shall be served by an independent impoundment space. More than one LNG tank within a common dike shall not be permitted."

Respondents urge deletion of the above prohibition, and they recommend the addition of language which they avouch would assure that, if more than one tank were placed in a common dike, no additional hazard would result. Respondents' version of Subsection 193.427(a) would read:

"Each LNG storage tank shall be served by an independent impoundment space unless provision is made to prevent low temperature or fire exposure resulting from any one tank served from causing subsequent leakage from any other tank served."

The staff offers the following rationale for requiring separate impounding space:

"If an LNG tank failed in an emergency, its independent impounding space would be able to contain the spilled liquid. If vapor from the spill were to catch fire in that **[*108]** area, the fire could be more easily controlled in a way to avoid damage to an adjacent LNG tank or its insulation. If, on the other hand, the two tanks were in the same impoundment area, the second tank would be more likely to be exposed to a hazard, either low temperature or fire."

Under respondents' proposed wording it would be permissible to have a design configuration in which storage tanks would have a common impoundment but be separated by a low dike. The staff witness pointed out that such a design would not satisfy the requirements of the staff's proposal for this subsection. He cited an example of such a design in Plymouth, Washington, where two LNG tanks have a common impoundment divided by a low common dike. He testified that spilled LNG from one tank would flow into the common impoundment area and that, if the spill ignited, the deluge system on the second tank would be triggered immediately to prevent damage to its structure or insulation. According to the staff witness the water from the deluge system would enter the pool of burning LNG and accelerate vapor evolution thereby increasing the hazard to the second tank. The staff witness further testified that with **[*109]** a common impoundment it would be possible for a spill from one tank to result in low-temperature exposure of both tank foundations, which depending on design characteristics, could result in the failure of both tanks.

Based upon the evidence, we agree with the staff on this issue. We will adopt Section 193.427 as proposed by the staff.

F. Part III, Subpart G - Design of Transfer Systems

1. Section 193.601 - Scope

Subpart G prescribes requirements for the design and installation of certain transfer systems in LNG facilities. As proposed by the staff, Section 193.601 would provide that Subpart G applies to "flammable fluids or cryogenic refrigerants."

The issue relating to this section is whether liquid nitrogen transfer systems should be subject to the requirements of Subpart G. The staff believes that liquid nitrogen transfer systems should be included becuse it views the free release of liquid nitrogen as a potential threat to the safety of plant personnel. The staff brings out that the temperature of liquid nitrogen is minus 320 degrees Fahrenheit and that injury could result from workers coming into contact with a pool of the liquid. The staff also points out **[*110]** that vaporized liquid nitrogen could produce asphyxiation.

Respondents contend that the stringent design requirements of Subpart G should be related to LNG and flammable refrigerants. Respondents urge that Section 193.601 be modified so that liquid nitrogen transfer systems will not be subjected to design requirements intended for LNG and flammable refrigerants.

It is a fact that liquid nitrogen is not flammable and to that extent is clearly not as hazardous as flammable refrigerants. We agree with respondents' position. We will adopt the following version of Section 193.601:

"This subpart prescribes requirements for the design and installation of LNG and flammable refrigerant transfer systems in LNG facilities as applicable under Section 193.3."

2. Section 193.605 - Shutdown Control Systems

Subsection 193.605(a) would require each transfer system to have an automatic shutdown control system to be activated when certain events specified therein (e.g., a piping failure) occur. In addition to specifying those events which require the activation of the control system, Paragraph 193.605(a) (6) also would require that the system be activated upon the occurrence of an "other **[*111]** condition indicating an accidental spill."

Respondents complain that the proposed Paragraph 193.605(a) (6) gives the designer of the control system no guidance. They contend that the designer is simply left to speculate as to what is meant by "other condition" and the operator would have no way of knowing whether or not its design complies with that requirement. Respondents assert that it is a meaningless requirement which should not be adopted.

We agree with respondents' position on this issue. We will delete Paragraph 193.605(a) (6) from this section.

G. Part III, Subpart K - Construction, Inspection, and Testing

1. Section 193.1025 - Nondestructive Tests

a. Subsection 193.1025(b)

This section prescribes requirements for testing storage tank welds. In general it adopts the requirements of API 620 n19, which governs the inspection of storage tank welds. Appendix A of that standard permits spot radiography of horizontal welds. The staff proposal, however, would require that those welds be 100 percent radiographically or ultrasonically tested.

n19 American Petroleum Institute Standard 620, "Recommended Rules for Design and Construction of Large Welded, Low Pressure Storage Tanks, Fifth Edition, July 15, 1977 (ANSI B 184.1). This standard has been received into this record by reference as Item O-F.

**[*112]**

The rationale underlying the staff's greater testing requirement is based on the assumption that LNG storage tanks at California sites would be exposed to greater seismic loading than at sites elsewhere in the United States.

The record shows that horizontal welds have a lower failure potential because they are not subject to the stress levels that vertical welds are. Horizontal welds are made by precision, automatic machines which produce welds of a much greater degree of consistency than the manual techniques which are used for vertical welds. For these reasons vertical welds require more rigorous testing than horizontal welds.

An expert witness sponsored by respondents on this subject expressed unequivocal confidence in the weld testing requirements of API 620. Another expert witness produced by respondents testified that requiring radiographic inspection of 100 percent of the horizontal welds could substantially disrupt the construction schedule and would increase the cost of tank weld inspections by $ 1.5 million.

The issue here appears to require a balancing of safety and extra cost. The record indicates that radiographic inspection of 100 percent of the horizontal welds would **[*113]** afford an extra degree of safety to the operation of the LNG tanks. This must be balanced with an extra cost of $ 1.5 million. We believe the extra safety to the public will be well worth the extra cost. We will, therefore, adopt the staff's proposed Subsection 193.1025(b).

b. Subsection 193.1025(c)

The staff proposes in this subsection that terminal operators be required to inspect a minimum of 10 percent of fabrication and 10 percent of circumferential butt welds of liquid nitrogen piping by radiography. This is a doubling of the requirements of ANSI B 31.3, n20 which is incorporated by reference in the staff's proposed regulations. If this subsection were not included in the adopted regulations, the requirements of ANSI B 31.3 that 5 percent of fabrication and circumferential butt welds be tested radiographically would be applicable. Respondents urge that Subsection 193.1025(c) not be adopted.

n20 ANSI B 31.3, "Chemical Plant and Petroleum Refinery Piping," 1976 edition and B 31.3a - 1978 addenda of the American National Standards Institute are incorporated in this record as Item O-E.

The record shows that liquid nitrogen piping at LNG facilities is generally small, **[*114]** and that such piping is operated at pressures less than 100 psig. It also shows that liquid nitrogen piping is usually not intermingled to any

great extent with process piping. Given these facts, it does not appear that liquid nitrogen piping at LNG facilities presents any unusual or unique hazards. We are of the opinion that the ANSI B 31.3 testing requirement is adequate. We will delete Subsection 193.1025(c) from the adopted regulations.

2. Section 193.1031 - Storage Tank Tests

Section 193.1031, as proposed reads, in part, as follows:

"(a) In addition to other applicable requirements of this subpart, metal and concrete low pressure LNG and flammable liquid storage tanks shall be tested in accordance with Section Q.8 and Q.9 of API 620, Appendix Q, as applicable, except that --

"(1) It is intended to test each of the LNG tanks to maximum design loads as specified in Subpart B, considering that the environmental loadings not occur simultaneously with each other for test purposes. Each LNG tank sahll be hydrostatically tested at the maximum water level but not exceeding the maximum design liquid level and the limitations allowed in Paragraph Q.8.1.1 of API 620, Appendix **[*115]** Q."

Respondents bring to our attention an apparent redundancy in the quoted portion of this section. Subsection 193.1031(a) adopts the hydrostatic testing requirements of API 620, Appendix Q, and Paragraph 193.1031(a)(1) adopts the same requirements. While it appears that Paragraph 193.1031(a)(1) is merely redundant, a closer examination of this issue indicates that the paragraph would serve a significant safety purpose.

As explained in the staff's opening brief, the issue here is the nature of the API 620 hydrostatic test to be undertaken, not whether the test should or should not be required. We agree with the staff that Paragraph Q.8.1 of API 620, Appendix Q requires an operator to test a tank by filling it with water to its design LNG liquid level. This test would be subject to the limitations allowed in Paragraph Q.8.1.1 of API 620, Appendix Q. Respondents, on the other hand, interpret Paragraph Q.8.1 to require a less rigorous test. Under their interpretation, the operator would fill the tank with water only until the weight of the water equaled the weight of a volume of LNG which would fill the tank to its design LNG liquid level.

Paragraph 193.1031(a)(1) restates for clarity **[*116]** the staff's interpretation of the hydrostatic test required by Paragraph Q.8.1. We do not believe that the paragraph serves merely to "impose some unspecified additional requirement" as respondents allege. We will adopt, therefore, the staff's proposed Paragraph 193.1031(a)(1).

H. Part III, Subparts L, M, and N - Operations, Maintenance, and Hazard Protection

1. Subpart L - Operations

Section 193.1105, as proposed by the staff, would require the terminal operator to develop certain operating procedures. Subsection 193.1105(h) specifies certain matters (e.g., use of the fire control system) which must be addressed in the procedure for each operation. Paragraph 193.1105(h) (2) would require procedures for,

"(2) Normal start up, operation, and shut down of each critical component and major system in the facility."

Respondents state that they do not object, in substance, to the imposition of this requirement. As was previously discussed in this opinion, respondents contend that the term "critical component" is so vague that it is meaningless. This issue was effectively resolved by our electing to retain the term "critical component" among the definitions included in Section **[*117]** 193.5. We will therefore adopt Paragraph 193.1105(h)(2) as proposed by the staff.

2. Subpart M - Maintenance

Section 193.1219 of this subpart includes a highly controversial staff proposal concerning the periodic inspection of LNG storage tanks. Subsection 193.1219(3), which would require the inspection of the inner tank material, reads as follows:

"At intervals not to exceed ten years, the tanks shall be inspected internally or with an alternative technique accepted by the Commission. The internal inspection shall be made and reported upon by competent outside inspectors not regularly in the employ of the utility who are selected by the utility and are agreeable to the Commission. The design of the LNG tank shall provide for entry in the inner tank."

The staff contends that tank inspections must be made every ten years to assure that continued operation of the tank will not lead to a disastrous failure and that the public would be imperiled if the Commission were to permit large LNG tanks to be filled and emptied many times per year without positive evidence that the tank is in acceptable condition.

The staff states that the proposed wording, "the tanks shall be inspected **[*118]** internally or with an alternative technique accepted by the Commission," is intended to encourage operators to develop non-destructive inspection techniques which could be effectively substituted for internal tank entry. The staff believes that its approach would give a high degree of assurance that LNG tanks do not have undetected corrosion, cracks, strains, or distortions which could lead, in time, to tank failure from the stresses of many thermal cycles, settling, and seismic activity.

Respondents argue that the periodic internal storage tank inspection requirement proposed by the staff is ill conceived and technologically unacceptable and, therefore, should not be adopted by the Commission. They contend that, despite the language about alternative techniques, this proposed regulation would require internal tank inspections because, as the evidence shows, no such techniques are available today.

Since alternative techniques are not now available, respondents pose two questions concerning this section: (1) What essential purpose would be served by such inspections? and (2) Would internal tank inspections be cost beneficial?

In examining the first question, the record is quite **[*119]** clear that, insofar as corrosion is concerned, no purpose would be served by internal tank inspection. In fact, more corrosion would probably ensue from tank entry than from the containment of LNG. This would follow because during containment the inside surface of the inner tank is in contact only with methane in its liquid and gaseous states and, depending on tank design, the outside surface is in contact with either methane or nitrogen. Hence, no air or corrosive substance touches the surfaces of the inner vessel.

It is also clear on this record that detection of tank buckling is not a justifiable basis for requiring internal inspection. Buckling is a bending or kinking of the storage tank, causing a permanent deformation. Buckling could result from only a severe external occurrence, such as an earthquake above the SSE n21 level, and the operator would obviously know of such an occurrence. In any case, Subsection 193.09(f) requires that a seismic recorder be installed at the facility, and an SSE level earthquake is an event which would require an immediate internal inspection.

n21 "SSE" refers to Safe Shutdown Earthquake, a term which is defined in Section 193.5. In essence, it is the earthquake which will produce the greatest ground shaking at the site.

**[*120]**

Other events which could cause buckling, such as a significant settling of the foundation or a meteorite striking the tank, would be readily detected by the instrumentation and other tests required by the general order.

As to cracks in welds or plates, the only cause, other than a major natural or man-made event (which would be known to the operator) would be flaws so small that they were undetected at the time of inspection. With the strict welding procedures and inspection techniques required by API 620 and the amended general order, it would be extremely unlikely for any significant cracks to be present following construction. The evidence shows that any cracks large enough to leak would be detected by the required hydrostatic and leak tests.

The testimony of a SDG&E witness developed in considerable detail the growth of cracks in an LNG tank. He testified that fracture mechanics analysis shows that cracks grow very slowly in response to stress changes within the tank, e.g., those resulting from the liquid level changes due to emptying and filling of the tank. For one of SDG&E's LNG tanks, a crack six-tenths of an inch long (large enough to cause a detectable leak) would grow **[*121]** only 6 millionths of an inch per year). According to him, even if cracks too small to leak were present in an LNG tank, they would be unlikely to grow to sufficient size to leak. Thus, the thrust of his testimony is that not only are cracks extremely unlikely but proven methods are available to determine if a leak has occurred.

The utilities point out that there are inspection techniques other than internal inspection available to detect a leak from the inner vessel of an LNG tank. Such a leak would be detected by the routine inspection methods required by Subsections 193.1219(1) and 193.1219(2), which require weekly visual inspections for frost spots. n22 Additionally, they point out that tests conducted regularly, in tanks similar to design to SDG&E (i.e., those with a nitrogen filled annular space), monitor the composition of the atmosphere in the annular space. Such tests would indicate the presence of methane and would thus indicate the possibility of a leak or crack in the inner tank.

n22 Frost spots are evidence of cold migration from the inner tank to the wall of the outer tank resulting in condensation of moisture in the air and frost on the surface of the tank. Such frost spots could be due to insulation settlement or a crack in the inner vessel.

**[*122]**

The evidence indicates that if a leak were detected, the operator should have ample time to take corrective action. The record is clear that a leak does not necessarily indicate an immediate safety hazard. SDG&E's witness testified that fracture mechanics analysis shows that if a detectable crack develops, it would take many years to grow enough to create a hazard to the facility, facility personnel, or the general public. According to the record, a crack six-tenths of an inch long which would permit the escape of a significant and detectable amount of methane, would require on the order of 100,000 operating stress cycles to grow to the critical crack length at which rupture of the tank could occur. The time involved in so many fill-and-empty cycles would far exceed normal LNG plant life expectancy.

The record shows that the staff and one of its consultants reviewed other codes to determine if any jurisdictions required a periodic direct inspection of the integrity of the inner tank material of LNG storage tanks. Except for a technique in New York unacceptable to the staff and a thickness test previously required in California, neither the staff nor its consultant was able to **[*123]** locate any requirements for such tank inspection.

As to the second question (Would internal tank inspections be cost beneficial?) SDG&E presented some significant evidence. The testimony of SDG&E's witness shows that an internal inspection of one of SDG&E's LNG tanks which would provide useful information would cost approximately $ 2 million for outside contractors, consultants, and equipment, and would take the tank out of service from four to six months. This witness also testified that a tank entry poses significant hazards to the personnel involved. Such an inspection would generally involve entry into the tank in a nitrogen atmosphere with the only access through a 24-inch diameter manway at the top of the tank, 120 feet from the floor. Scaffolding would have to be erected inside the tank to permit access to the welds on the tank sides and dome. All work inside the tank would be performed with the operators in full life support gear due to the lack of air. In addition, he pointed out that there are risks of damage to the tank.

We would accept the staff's proposal if inspection of the inner tank were straightforward, safe, and reasonable in cost. However, to require an entry **[*124]** when all other inspection techniques indicate no problem with the inner vessel would be unjustifiable economically and operationally. We will, therefore, adopt respondents' proposed modifications to Section 193.1219.

The staff witness testified that certain methods employing instrumentation and other devices are presently available to continuously monitor the cold propagation and stress development on the surface of the inner tank. The record shows that some operators of LNG tanks already have installed such instrumentation on their LNG tanks. Since periodic internal tank inspection will no longer be required, we will require SDG&E and Western Terminal each to submit a plan, to be approved by the Commission, for the monitoring of the integrity of LNG tanks, whether by instrumentation for continuous monitoring, periodic pressure testing or other acceptable means. This will be in addition to requirements set forth in 193.1219. Western Terminal will be required to file its monitoring plan during the safety and construction review. However, the provisions of prior Commission Decisions will remain applicable to the LNG tanks of SDG&E until SDG&E's monitoring plan is approved by the **[*125]** Commission.

3. Subpart N - Hazard Protection

a. Section 193.1307 - Hazard Analysis

Subpart N centers its requirements around a hazard analysis, as proposed in this section. On the basis of the evaluation made in the hazard analysis, the protection needed for each facility would be provided. This section reads, in part, as follows:

"Hazard protection shall be provided for all LNG facilities. The extent of such protection shall be determined by an evaluation made in consultation with appropriate government agencies and based on sound fire protection engineering principles, analysis of local conditions, hazards within the facility, and exposure to or from other property."

SDG&E takes particular exception to this proposed section because of the effects it could have on its existing LNG facility. SDG&E concedes that hazard analysis has considerable merit and supports the concept of such analysis. However, SDG&E has made its own proposal for hazard analysis by recommending incorporation of Section 901 of the proposed amendments to the next edition of NFPA 59A n23. This same Section 901 appears to be the model from

which the staff patterned its proposed Section 193.1307, and, **[*126]** although the basic requirements for a hazard analysis in the two proposals are parallel, SDG&E finds problems of significance with the staff proposal.

n23 See Item O-BBB, which is a complete copy of the proposed amendments to NFPA 59A. The NFPA's Committee on Liquefied Natural Gas has approved extensive amendments to NFPA 59A-1975 and proposed them for NFPA adoption in November 1979. These will be published by NFPA in February 1979 in its Technical Committee Reports for public review and comment. Any comments received will be acted upon by the Committee in April 1979 and the Committee action thereon will be published prior to November 1979. Although Item O-BBB is a draft document, the finalized copy is likely to be published without change from the draft.

According to SDG&E, the staff's requirement of a hazard analysis through Subpart N rather than through NFPA creates problems of confusion and uncertainty arising from proposed Section 193.3(c) which provides:

"(c) The requirements in Subparts C through K and P of this part for the modification, repair, or replacement of critical components within facilities which are in operation on the effective date of this part, shall apply **[*127]** to the component modified, repaired, or replaced to the extent practical."

SDG&E contends that this section has implications which are "far reaching and undefined." SDG&E asserts that the definition of "critical component" in Section 193.5 is "vague and all inclusive." SDG&E interprets the definition as including "among other things, everything in an LNG facility whose failure could cause a release of LNG," thus making Section 193.3(c) "apply to nearly every piece of equipment in the plant, most instrumentation, and all LNG piping, as well as utility support systems and backup systems." Further, SDG&E contends that since the term "component" is not defined, a "component" is merely part of a larger whole and has no meaning which would limit the scope of the staff's proposed Section 193.3(c).

The primary problem SDG&E has with the staff's proposal concerns its application to SDG&E's facility if a change is made. SDG&E fears that "regardless of the staff's current intent, it is simple to interpret their code so that a small change in one portion of an existing LNG plant could cause the proposed regulations to apply to a much larger segment of the plant than the portion modified."

Because **[*128]** the term "component" is subject to broad interpretation, SDG&E believes that it will be faced with continual problems as to how to apply the regulations to its existing facility. SDG&E cites as an example, a situation where it would decide to replace, for routine maintenance purposes or improved performance, some item of equipment within its emergency shutdown control system. SDG&E is concerned that the staff, which would interpret the code at that time, may decide that the "component" modified is the entire shutdown control system rather than only the specific item replaced. If such an interpretation were made, SDG&E contends that extensive modifications, not related to the original item replaced, would be required of SDG&E's emergency shutdown control system to comply with Section 193.915 and that these modifications would be extensive but would not necessarily increase the safety of the facility.

It is SDG&E's position that this problem is further compounded if it involves changes within the scope of Subpart N. SDG&E cites an example where its hazard analysis might suggest minor modifications to the LNG storage tank dike configuration to reduce vapor dispersion. SDG&E expresses **[*129]** the fear that the staff might determine that the entire impoundment system was the "component" modified, not just the portion of the dike changed to reduce vapor dispersion. This interpretation would require SDG&E to modify its dikes to comply with the provisions of Subpart E, and such modifications would not even be limited by practicality because they would be done to comply with Subpart N, which mandates compliance without any limitation whatsoever.

SDG&E asserts that such interpretation problems could have a significant and undesirable impact on the operator's attitude about changing and improving its plants, in that the operator would be confronted by a complicated dilemma. Maintenance, which includes regular replacement of certain components, and safety modifications are normally done on a routine basis. However, if the staff position were adopted by the Commission, SDG&E states that such changes would no longer be routine; that, instead, each change would require a careful evaluation to determine whether additional expensive modifications may be triggered.

Apart from the negative aspects of the staff proposal, SDG&E asserts there are significant affirmative reasons why its **[*130]** proposal is far superior. As an example, SDG&E points out that the staff proposal contains no requirements for modifying existing facilities apart form the Subpart N hazard analysis and that, therefore, so long as no modifications, repairs, or replacements are completed, no portion of the facility need be upgraded to present technology.

SDG&E states that its own proposal would require compliance to the extent practical with the current edition of NFPA 59A and that current state of the art safety improvements would be assured by requiring compliance to the extent practical with the upcoming edition of this NFPA standard.

We find insurmountable problems with SDG&E's proposal. This Commission does not have before it a final, approved version of the next edition of NFPA 59A which the utilities recommend should be the safety standard for existing facilities. This Commission cannot be assured that the next edition of NFPA 59A, which will not be promulgated until late 1979, (or other future additions) will not contain unacceptably low safety requirements. Likewise, this Commission has before it no explicit evidence on the nature and requirements of a hazard analysis evaluation that **[*131]** might be required by the next edition of NFPA 59A. We will, therefore, reject the utilities proposed changes to Subsection 143(j), to Section 193.3, and Section 193.307. However, we will add the qualifier "to the extent practical" to the first sentence in Section 193.1307.

Although we are rejecting the specific requests of the utilities with regard to this section, SDG&E may rest assured that this Commission has no intention of permitting these safety regulations to be applied in a manner which would be a disincentive for making plant improvements or performing necessary maintenance. Our intention is that these regulations will be administered in a manner which will, on the one hand, assure the public that LNG facilities will be maintained in a manner consistent with the latest technology and, on the other hand, assure the utilities that insignificant changes in an LNG facility will not trigger unreasonable changes in a larger portion of the plant.

b. Section 193.1311 - Hazard Warning and Response

Staff proposed Subsection 193.1311(d) would provide as follows:

"Upon activation of the seismic recorder beyond a predetermined level reviewed by the Commission, automatic shutdown **[*132]** of the facility shall commence."

The main issue here is whether seismic activity should be one of the hazardous conditions that actuates automatic facility shutdown. The staff recommends that an LNG facility be shut down automatically when an onsite seismic recorder senses seismic activity equal to or greater than a force to be determined by this Commission. Respondents recommend deletion of this subsection, thus eliminating the requirement of automatic shutdown due to seismic activity.

Establishment of a requirement for automatic shutdown because of seismic activity raises the corollary issue as to what level of seismic activity should trigger shutdown. The staff recommends that an LNG facility should automatically shut down upon sensing a peak acceleration not more than 10 percent greater than the OBE.

The staff contends that the requirement for an automatic shutdown upon a predetermined level of seismic activity is necessary for reasons of safety of the public and plant personnel as well as continued safe operation of the facility. Staff witness Dr. Young testified that the operator would have no assurance that the LNG facility would remain in a safe operating condition following **[*133]** an earthquake above the value of the OBE. The staff argues that, unless the shutdown is automatic, this Commission and the public would have insufficient assurance that the plant actually would be shut down so as to reduce the chances of a consequent catastrophic event. They point out that, if a manual shutdown following a seismic event is relied upon, human error or injury could prevent plant shutdown for an unacceptably long period. The staff position is that, by adoption of the concept of automatic shutdown, this Commission can make a clear and definite statement of the level of seismic activity at which an LNG facility should be shutdown for detailed inspection by the operator and the staff to assure that the facility is in, or has been restored to, a safe condition prior to resumption of operation.

The automatic shutdown, as proposed by the staff, would be a systematic, sequential shutdown of the facility following the sensing of the seismic activity. It would not be a requirement to stop all processes immediately and simultaneously, which could create water hammer in the flowing liquids.

The staff states that its recommendation of 110 percent of the OBE as the level of seismic **[*134]** activity which would trigger shutdown is meant to apply to new LNG facilities only. The level at which existing facilities would be automatically shutdown would be determined individually for each such facility.

A potential hazard could become an actual hazard during aftershocks which frequently follow strong earthquakes, unless an inspection period were to follow the seismic event. During the inspection period, weakened and potentially hazardous structures and components would be noted for repair or removal prior to resumption of the flow of LNG and vapor through the system. Without such repair or removal a weakened structure could collapse around or on to a critical

component. Automatic shutdown would allow such action to be taken. Therefore, we will adopt the staff's proposed Subsection 193.1311(d).

IV. MONITORING PROGRAMS

A. Commission Staff Proposals

The staff introduced Exhibit No. 0-76, "Report On the Safety and Construction Monitoring Program of Western LNG Terminal Associates' Liquefied Natural Gas Facilities at Point Conception", in these proceedings. That exhibit contains a detailed description by the staff of how it proposes to organize and conduct its **[*135]** safety and construction monitoring program. The staff also introduced Exhibit No. 0-164, "Report on the Evironmental Monitoring Program of Western LNG Terminal Associates Liquefied Natural Gas Facilities at Point Conception", in these proceedings. Exhibit No. 0-164 is intended by the staff to be incorporated as Chapter 4A in the report contained in Exhibit No. 0-76.

Exhibit No. 0-76 describes the "Scope" of the staff's proposed safety and construction monitoring program (SACMP) as follows:

"1. The CPUC's Construction Monitoring Program (Monitoring Program) will include the review of design, construction, and operational start up of the LNG terminal and associated pipeline to be constructed in California. The staff assigned to the Monitoring Program will cooperate with the state, local, or federal agencies who may have jurisdiction over functions such as safety of employees on the site, security protection, environmental protection, or fire suppression and control.

"2. The CPUC staff in this proceeding will submit proposed minimum standards of design and construction for LNG facilities located within the State of California for consideration and adoption by the Commission. The **[*136]** proposed natural gas pipeline will be designed and tested in accordance with the requirements set forth in the Commission's General Order No. 112-C, relating to rules governing design, construction, testing, maintenance, and operation of utility gas gathering, transmission, and distribution piping systems."

The staff states that the SACMP personnel will interface with the Commission's cost monitoring team n24 in assessing changes in the design of the LNG terminal.

n24 The duties and responsibilities of the cost monitoring team are described in Exhibit No. A-46. Funding for the Commission's monitoring programs was provided for in Condition 13 to the permit granted in Decision No. 89177.

The following "Basic Plan" for the proposed SACMP is spelled out in Exhibit No. 0-76:

"The CPUC's Program will be divided into two groups - a design review group and a construction review group, which will also include the operational start up of the LNG terminal. After completion, safety review of the proposed LNG terminal will be handled by personnel of the Safety Section within the Gas Branch of the Utilities Division of the Commission; or in the alternative, a section dealing specifically with **[*137]** LNG facilities may be created. In order to ensure compliance with the minimum design and safety standards established by the Commission, the design review group will have the responsibility of reviewing and commenting upon the plans and specifications. This group will also review and comment upon WLNG's proposed procedures for start up and operation of the terminal and will review the off-site materials testing. The construction review group will have the responsibility for monitoring the materials testing and construction inspection at the LNG terminal site. Additionally, the construction review group will monitor the testing of the various systems and the operational start up of the terminal.

In Exhibit No. 0-76 the staff describes the scope of the proposed design review portion of the SACMP as follows:

"Assuming a permit is granted to WLNG to construct and operate the proposed LNG terminal, the Staff will review design computations and plant layout to ensure that the designed facility complies with the minimum design and safety standards established by the Commission. This will require WLNG to provide the CPUC with copies of all contract documents, plans, and specifications **[*138]** with adequate supporting documentation to enable the Commission Staff or its agents (Staff) to adequately review these documents. The Staff will check the necessary documents in a review program that will cover a wide scope yet vary significantly in depth to ensure that the documents comply with CPUC's safety standards, design criteria, appropriate codes, and other sound engineering practices."

The staff states that its proposed design review will involve checking the necessary documents in a review program that will cover a wide scope to ensure that the documents comply with the Commission's adopted safety standards, design criteria, appropriate codes, and sound engineering practices. The staff intends that the construction monitoring will assure compliance with the engineered design as well as make certain that various systems and components are tested for strength and proper operation.

The proposed monitoring program also provides for reviewing operating and maintenance procedures. The staff points out that, for continuous, safe operation of an LNG facility, it is important that the operation and maintenance procedures are properly formulated and provide for corrective actions **[*139]** to correct hazardous conditions. The staff states that its proposed SACMP would require only an absolute minimum review of design, engineering, construction, testing, start up, hazard protection, and operating and maintenance procedures of the Point Conception LNG facility. The staff contends that a lesser review than it proposes would be absolutely unacceptable and that the proposed review is required to protect the public health, safety, and welfare.

B. Respondents' Recommended Changes

Respondents contend that the scope of the staff's proposed monitoring program is excessively broad. They allege that the scope of the staff's monitoring responsibilities, as stated in Exhibit No. 0-76, clearly exceeds the Legislature's intended scope for the monitoring program. In support of their position, respondents cite Public Utilities Code Section 5637 and assert, "Thus, it is clear that the Legislature intended that the monitoring program be adopted in order to assure that the terminal constructed pursuant to the Act complies with (1) the safety regulations to be adopted by the Commission in these proceedings, and (2) any terms and conditions attached to the permit issued **[*140]** by the Commission."

In support of their allegations that the staff would assume responsibilities far exceeding the statutory purposes for the establishment of the SACMP, respondents cite, as an example, that in the scope of the design review, as detailed in Exhibit No. 0-76, the staff proposes to review Western Terminal's design for compliance with such concerns as "design criteria", "appropriate codes", and "other sound engineering practices". As a further example, they cite that in Exhibit No. 0-76 the staff proposes to monitor Western Terminal's engineering plans and drawings "for compliance with the adopted criteria, appropriate safety codes and other statutory requirements".

In addition to their allegation that the staff would clearly exceed the Legislature's intended scope for the program, respondents put forth the following as practical reasons why the proposed SACMP should be rejected by the Commission:

". . . First, whereas Staff will certainly have expertise in monitoring for compliance with the Commission's reguations and terms and conditions, it does not necessarily possess the same level of expertise as it relates to 'other statutory requirements' and 'appropriate **[*141]** codes' which may have been adopted by other governmental bodies. Second, if the staff were to review WLNGTA's efforts for compliance with such vague and elusive criteria as 'sound engineering practices', WLNGTA's personnel would not know what requirements they are to satisfy."

Respondents contend that the scope of the proposed monitoring program is also ill defined, and as such, would encourage the staff to unnecessarily duplicate the safety and quality assurance efforts of Western Terminal. They quote the following extract from Exhibit No. 0-76 in which the staff provides a general statement of intent concerning the relationship of its monitoring program with Western Terminal's own efforts to assure the design and construction of a safe terminal:

"WLNG, as owner-operator of the proposed terminal, will have the ultimate responsibility for the safety of the facility. Such responsibility necessitates extensive design analysis and construction inspection procedures on the part of WLNG. The CPUC's Program is designed to review and audit these procedures as necessary for this facility."

Respondents point out that there are numerous instances in the proposal where the staff defines **[*142]** its monitoring activities to include detailed reviews of virtually all documentation related to design and construction activities of Western Terminal. They cite, as examples, that at page 3-1 of Exhibit No. 0-76 the staff would require Western Terminal to submit copies of all engineering plans and drawings, and that at page 3-2 the staff would review all supplemental contract documents such as suppliers working drawings, specifications contained in bid requests, and proposed changes in the construction of the LNG terminal. It is respondents position that such activities go well beyond the stated intent of the staff to emphasize auditing of Western Terminal's procedures and that they clearly would involve an unnecessary and wasteful duplication of Western Terminal's safety and quality assurance control efforts.

The staff alleges that respondents' internal safety and quality assurance programs are incomplete because respondents failed to include in its Exhibit No. 0-163 copies of the manuals which contain the detailed procedures to be followed in the implementation of these programs. Respondents challenge this allegation. They assert that the exhibit was intended as a general **[*143]** overview and was never intended to be a proposed safety and quality assurance program for the staff's review and use. Respondents state that they will engage in extensive safety and quality assurance efforts that will obviate the need for staff duplication of their efforts. They point out that it would have been premature for them to develop detailed safety and quality assurance programs until the proposed Section 193.1003 n25 is finalized.

n25 Proposed Section 193.1003 would impose specific requirements for the safety and quality assurance program.

c. Staff Motion to Strike Respondents' Proposal

As Appendices C and D to their opening brief, respondents have filed documents that extensively revise the staff's SACMP and environmental monitoring program proposals. Appendix C contains respondents' recommended monitoring programs. Appendix D contains the staff's recommended programs with language found objectionable by respondents interlined and their substituted language underlined. These appendices, taken together, constitute respondents' proposal for a safety, construction, and environmental monitoring program to be undertaken by the staff at the Point Conception LNG **[*144]** facility site.

In the two appendices respondents present for the first time the specific changes that they propose be made to the monitoring programs presented by the staff in Exhibits Nos. 0-76 and 0-163. These exhibits are lengthy documents and respondents propose literally hundreds of changes to their text and format. Respondents assert that the record as made supports making this multitude of changes, many of which are substantive in nature and far reaching in effect.

The staff objects to the introduction of these new proposals at this point in this proceeding. It contends that the appendices are an attempt by respondents to put new evidence in the record after the submittal of Phase II of these proceedings. The staff points out that respondents have offered no witness to sponsor their proposal on the record and that no party has had an opportunity to undertake cross-examination to test its validity. For these reasons the staff moves to strike the appendices from the record and recommends that the Commission take no notice whatsoever of Appendices C and D to respondents' opening brief.

We agree with the staff position that the two appendices represent an attempt to put **[*145]** new evidence in the record after submittal of this phase of the proceedings. Respondents failed to offer witness to support their proposal, and no party was afforded an opportunity to test the validity of the proposal through cross-examination.

We hereby grant the staff motion to strike from the record Appendices C and D to respondents' opening brief.

We will adopt the staff's safety, construction, and environmental monitoring programs as proposed in Exhibits Nos. 0-76 and 0-164, appropriately modified to conform to the other provisions of this decision.

D. Staffing and Organization

The staff in Exhibits Nos. 0-76 and 0-164 includes a presentation on the staffing requirements and organizational structure for its proposed monitoring program. This presentation is not relevant to the issues in this proceeding. The staffing and organization of the monitoring program are administrative matters which this Commission will determine routinely in connection with its overall budgeting and manpower resources and needs. Accordingly, the monitoring program we adopt herein will omit those portions of the staff proposal which detail staffing requirements and organizational structure. **[*146]**

V. DESIGN GUIDELINES

The Commission staff sponsored Exhibit No. 0-142 entitled "Design Guidelines for Sections 193.119 through 193.137 of Proposed Part III Liquefied Natural Gas Facilities Safety Standards of General Order No. 112-C."

The purpose and scope of these guidelines is found in the Introduction and Summary of Exhibit No. 0-142, which reads:

"This report provides guidelines to assist the Operator in developing criteria for the design of Liquid Natural Gas (LNG) facilities to meet the requirements of Sections 193.119 through 193.137 of Part III of the Liquefied Natural Gas

Facilities Safety Standards of General Order No. 112-C. These sections of the Safety Standards and the Guidelines are primarily concerned with the design of LNG facilities to satisfactorily withstand the effects of earthquakes, winds, tornados, and floods. Other hazards are also briefly considered. It is important to note that the Guidelines are not a part of the Safety Standards and do not represent required procedures. The Guidelines do provide recommendations, which if followed by the Operator, should ordinarily result in design criteria that will be acceptable to the Commission. The Operator **[*147]** is encouraged to consider the Guidelines in the definition of design criteria for LNG facilities, but the Operator may provide other recommendations for meeting the requirements of Sections 193.119 to 193.137 of the Safety Standards."

The staff urges that this Commission "adopt" the design guidelines contained in Exhibit No. 0-142. The staff states its position as follows:

"The staff believes that these Design Guidelines will be an aid to an operator in that the path to design criteria acceptable to this Commission will be clearly marked. Misunderstanding causing costly delays can hopefully be alleviated through their use. The staff, therefore, recommends that this Commission promulgate these Design Guidelines for use with the safety standards."

Respondents take the position that it is inappropriate to adopt Exhibit No. 0-142 as Design Guidelines in their current form and at this time. In their reply brief, they advance the following reasons for their opposition to the Commission adoption of the Design Guidelines at this time:

"First, the Design Guidelines were originally transmitted together with Staff's proposed Safety Regulations (Exhibit 0-140) and, hence, presumably were **[*148]** prepared at the same time. During the course of this proceeding, numerous changes were made by Staff to its proposed Safety Regulations. Similar changes have not been made by Staff to the Design Guidelines (Exhibit 0-142). For example, classification definitions, found at pages 1-3 of the Design Guidelines, do not reflect modifications made to these definitions in Staff's version of the Safety Regulations. Similarly, the definition of OBE found at pages 2-3, has not been updated to reflect changes made by Staff in the Safety Regulations. Likewise, the requirements pertaining to seismic qualification tests, found at pages 3-36 of the Guidelines, and the requirement pertaining to allowable stress of brittle elements, found at pages 5-13 of the Guidelines, do not reflect subsequent changes made by the Staff in its proposed Safety Regulations. Hence, Exhibit 0-142 is out of date at this time. This fact alone justifies Respondents' opposition to Staff's motion.

"Additionally, as this Commission is aware, the Staff and Respondents differ on several significant points in the Safety Regulations, which dissagreements will have to be resolved by the Commission at the time it promulgates **[*149]** the Safety regulations. Since the purpose of Design Guidelines is to help interpret Safety Regulations and to guide applicants who must apply the Safety Regulations, the guidelines should be finally prepared only after the Commission has adopted a set of Safety Regulations. This will enable those preparing the Design Guidelines properly to reflect the Safety Regulations as ultimately promulgated.

"In summary, because the Design Guidelines in Exhibit 0-142 are already outdated and further because the Design Guidelines should be written or updated after the Commission promulgates its Safety Regulations, the Commission should not adopt Exhibit 0-142 as Design Guidelines. Respondents have no objection to Design Guidelines being developed subsequent to the Commission's adoption of Safety Regulations.

We cannot agree with respondents' position that the design guidelines should be finally promulgated only after we have adopted a code of safety standards. Exhibit No. 0-142 closely tracks the staff's proposed safety standards. While the safety standards we will adopt herein differ in a number of significant points from those proposed by the staff, we are presented with no difficulty **[*150]** in the task of having the design guidelines conformed to the safety standards we will concurrently adopt. We will, therefore, adopt the staff proposed design guidelines with appropriate modifications.

VI. INTERPRETATION OF DECISION NO. 89177

Condition 41 of Decision No. 89177 reads as follows:

"41. Critical Earthquake Intensity

"Condition:

"Western Terminal, in the design of critical LNG components, such as storage tanks, is directed to utilize accelerations associated with a 7.5 magnitude earthquake on the North and South Branches of the Santa Ynez fault

and/or on the F-1 fault. Accordingly, Western Terminal shall design all critical components to a peak bedrock acceleration of .7g (gravity) at the site."

Respondents preface their request for clarification with the observation that in Condition 41 both the word "design" and the word "peak" are used in describing 0.7g. Respondents state that, as written, this condition has raised some questions as to its exact meaning and intent. As justification for bringing the condition to issue in Phase II, respondents point out that Western Terminal will be bound by Decision No. 89177 in the construction and operation of the **[*151]** Point Conception facility; hence, they have taken the opportunity to present their interpretation of Condition 41 and to urge that their interpretation be formally adopted by the Commission.

In support of their assertion that Condition 41 requires interpretation, respondents point out that the staff modified its original definition of peak acceleration. The original term and definition is found in Exhibit No. 0-14- where the staff recommended a definition of the term "peak horizontal ground acceleration." Later in the proceedings, the staff's witness, Dr. Young and Dr. Slosson, urged that two terms, rather than one, be included in the regulation, namely, "design maximum acceleration" and "peak ground acceleration." n26 Respondents state that, thus, two terms, with distinct meanings, are now recommended by the staff in an attempt to eliminate confusion regarding the meaning of the term peak acceleration. Therefore, they assert that the provision in Condition 41 pertaining to desinging for peak bedrock acceleration has no clear and singular meaning associated with it.

n26 We conclude from the explanations of Drs. Young and Slosson and from the revised definitions that peak acceleration, to the geologist, is a single insolated peak, whereas, to the engineer, it is the design peak, of engineering significance, used to scale response spectra.

**[*152]**

We agree with respondents' position that Condition 41 requires clarification by interpretation. There is little question that Condition 41 has raised interpretive questions and Decision No. 89177 requires clarification with regard to the 0.7g figure in Condition 41. It is necessary that we undertake this clarification so that the decision can be properly implemented. We will examine this problem and in this opinion provide an interpretation of Condition 41 of Decision No. 89177 based upon the full record to date in these consolidated LNG proceedings.

In Exhibit No. 0-152, Dr. Newmark explained his interpretation of Condition 41. He recommended that a SSE having an effective peak, n27 as distinguished from actual or recorded, peak horizontal ground acceleration of 0.5g be used to scale respose spectrum of one standard deviaton above the median. Dr. Newmark expressed the belief that the values he recommended for design are consistent with Decision No. 89177.

n27 The term "effective peak" as used by Dr. Newmark is equivalent to the term "design maximum acceleration."

We do not agree. In Decision No. 89177 we found that critical components of an LNG facility should be designed **[*153]** for a maximum peak acceleration of 0.7g at Point Conception. This value shall be used as the design maximum acceleration to scale elastic response spectra.

VII. FINDINGS AND CONCLUSIONS

A. Findings of Fact

1. Except where it is incompatible with the specific findings below, we find that it is reasonable and consistent with the public health, safety, and welfare to reject the proposals of respondents and other parties and to adopt, in their entirety, the staff's proposed safety regulations, monitoring programs, and design guidelines.

2. Based upon the discussion in this opinion we find that it is reasonable and consistent with the public health, safety and welfare:

a. To delete the requirement, as proposed in Section 143(d) of the safety regulation and in Chapter 7 of the monitoring program, that LNG terminal operators prepare Final Safety Analysis Reports.

b. To modify the definitions of the terms "cargo transfer system", "transfer area", and "transfer piping" as proposed in Section 193.5, by deleting from each term the words "flammable fluids and cryogenic refrigerants" and substituting therefor in each term the words "LNG or flammable refrigerants."

c. To delete **[*154]** the definition of "design basis flood" as that definition appears in Section 193.5 of the proposed regulations.

d. To require the addition of the following definition to Section 193.5: "'Flame spread rating' refers to the numbers or classifications obtained according to the Method of Test of Surface Burning Characteristics of Building Materials (NFPA 255)."

e. To require the addition of the following definition to Section 193.5: "'Flammable gas' is any gas which will burn in the normal concentration of oxygen in the air."

f. To modify the definition of "flammable limits" proposed in Section 193.5 to read as follows: "'Flammable limits' are extreme concentration limits of a combustible in air through which a flame, once initiated, will continue to propagate at atmospheric pressure and temperature."

g. To delete the definitions of "causative fault" and "secondary fault" from Section 193.5 and to modify all other sections of the regulations to eliminate the terms.

h. To modify the definition of "safety related component" in Section 193.5 to read as follows: "'Safety related component' is a component the function of which is crucial to the maintenance of a safe operating or shutdown **[*155]** condition and to the prevention or control of hazardous conditions in an emergency."

i. To modify staff's proposals regarding Section 193.103, Section 193.105, Paragraph 193.113 (c)(3), Subsection 193.115(f), Section 193.119 and Section 193.123.

j. To adopt respondents' proposals regarding Paragraph 193.109(a)(2), Subsection 193.113(a), Subsection 193.113(b), Paragraph 193.113(c)(2), Subsection 193.113(d), Subsection 193.115(b), Section 193.133, Subsection 193.139(b), Subsection 193.323(b), Section 193.601, Paragraph 193.605(a)(6), Subsection 193.1025(c), and Section 193.1219.

k. To require Western Terminal and SDG&E to submit plans to the Commission for monitoring the integrity of LNG tanks.

1. To not include in the monitoring program adopted herein those portions of the proposal which relate to the staffing of that program.

3. The following findings are supportive of, and in addition to, the findings made in 1 and 2, above:

a. For the purpose of determining whether a fault is significant to seismic design (a capable fault) it is sufficient to consider its activity or inactivity during the past 100,000-140,000 years.

b. The determination of whether a site is geo-technically **[*156]** suitable for use as an LNG terminal should be based on an evaluation of all geological/seismological investigations and engineering studies.

c. No engineering or geologic rationale exists for the proposition that the geologic suitability of a site should be determined on the basis of a single criteria, such as causative fault as proposed by the staff.

d. Inclusion of the terms "causative fault" and "secondary fault" in the safety regulations would serve no useful purpose.

e. In preparing a design for seismic hazards, both the vibratory ground motion and the potential for surface displacement on faults must be considered.

f. Engineers can and do successfully design structures to withstand vibratory ground motion.

g. Although engineers can design structures for surface ground displacement, it cannot be done with the same level of confidence as for vibratory ground motion.

h. The decision whether critical components should be set back from any capable fault trace found at an LNG site and the proper setback distance, should setback be appropriate, must be determined on a case-by-case basis, predicated on the geologic and engineering analysis of the specific case, except that for LNG **[*157]** tanks a minimum 100 ft. setback is necessary.

i. Ground attenuation relationships used for determining earthquake vibratory ground motion, design of structures, and scaling of response spectra are mean relationships based on design maximum accelerations.

j. The most recent version of baseline horizontal response spectra, found in a 1976 paper, "Earthquake-Resistant Design of Nuclear Power Plants" principally authored by Dr. Newmark, should be included in the safety regulations.

k. Use of ductility factors for structures, components and systems would allow an imprudent erosion of the margin of reserve strength that will be incorporated in the seismic design.

l. A 50 percent increase in code allowable stress over normal working stress is appropriate for ductile elements in safety related facilities subject to SSE loads plus normal operating loads.

m. A probability based exclusion criterion to determine potential component functional impairment caused by a natural or man-made hazardous event is not suitable because probability analysis is not a sufficiently exact science.

n. A general design criterion is required to govern the design for natural and man-made hazards.

o. A three-part **[*158]** classification system which categorizes all LNG facility components according to their reliability characteristics and the potential safety hazards associated with them will simplify design and enhance plant safety and reliability.

p. Use of a 2.5% concentration of natural gas in air in a vapor dispersion model will provide adequate safety to the public at an LNG facility property line.

q. Experts who reviewed that portion of Commission Decision No. 89177 providing for a 0.7g peak bedrock acceleration concur that it is subject to various interpretations.

r. The proper interpretation of that portion of Decision No. 89177 providing for a peak bedrock acceleration is that 0.7g shall be used as the design maximum acceleration to scale elastic response spectra.

s. No human endeavor has zero risk associated with it. The risk which will be permitted to be associated with the construction and operation of an LNG terminal must be determined by a regulatory body.

4. To the extent that any finding made in 1, 2, or 3, above, is inconsistent with any portion of Decision No. 89177, the findings herein supercede that decision.

B. Conclusions of Law

Based upon the foregoing findings **[*159]** of fact, the Commission concludes that:

1. The safety standards, monitoring programs and design guidelines that we are adopting satisfy the requirements and meet the objectives of *Public Utilities Code Section 768*, 5632, and 5637 and General Order No. 112-C, Section 102.2 to promote and safeguard public health, safety and welfare.

2. Western Terminal and SDG&E should each submit a plan to the Commission for monitoring the integrity of LNG tanks.

VIII. ORDER

IT IS ORDERED that:

1. Within twenty days after the effective date of this order the Commission staff shall file with the Executive Director its proposed safety regulations (Exhibit No. 0-140), its proposed safety and construction program (Exhibit No. 0-76), its proposed environmental monitoring program (Exhibit No. 0-164) and its proposed design guidelines (Exhibit No. 0-142) modified to conform to the findings and conclusions of this decision.

2. The filing required by the prior paragraph, upon being made in good order, shall have the effect of:

a. Modifying Part I and Part II and adding a new Part III to General Order No. 112-C, which shall thereupon be designated General Order No. **112-D.**

b. Establishing the Commission's **[*160]** safety, construction, and environmental monitoring programs, and

c. Promulgating a set of construction guidelines for liquefied natural gas facilities.

3. The Executive Director shall mail to each respondent and each other party to these proceedings a copy of the filing made pursuant to Paragraph 1 of this order.

4. Within sixty days after the effective date of this order, San Diego Gas and Electric Company shall submit plans acceptable to the Commission for monitoring the integrity of LNG tanks by instrumentation for continuous monitoring, periodic testing, or other acceptable means.

5. Western LNG Terminal Associates shall prepare a plan for monitoring the integrity of its LNG tanks by instrumentation, periodic testing, or other means and submit it for design review by the Commission staff as part of the Safety and Construction Monitoring Program.

The effective date of this order shall be thirty days after the date hereof.

Dated at San Francisco, California, this 5th day of JUNE, 1979.

**Legal Topics:**

For related research and practice materials, see the following legal topics:
Energy & Utilities LawGas IndustryLiquefied Natural GasEnergy & Utilities LawTransportation & PipelinesPipelinesGeneral OverviewEnergy & Utilities LawUtility CompaniesContracts for Service