DEPARTMENT OF TRANSPORTATION

Research and Special Programs Administration

49 CFR Part 193

[Docket OPSO-46]

Liquefied Natural Gas Facilities; New Federal Safety Standards

AGENCY: Materials Transportation Bureau (MTB), DOT.

ACTION: Final rule.

SUMMARY: This final rule establishes a set of comprehensive safety standards governing the design (including site selection) and construction of liquefied natural gas (LNG) facilities used in the transportation of natural gas by pipeline in or affecting interstate or foreign commerce. Because of the grave consequences that could result from a major accident at a facility, present regulations are considered inadequate.

DATE: Effective date of this final rule is March 15, 1980, except for §§ 193.2119 and 193.2329 which will be made effective at a subsequent date.

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SUPPLEMENTARY INFORMATION: LNG is methane gas that has been cooled to about minus 260 degrees Fahrenheit where it occupies 1/600th of its original volume. LNG is hazardous because of its cold temperature, flammability, and dispersion characteristics upon release. Upon exposure to ambient temperatures, LNG vaporizes rapidly and the vapor may remain close to the ground and disperse into the atmosphere in the form of a cloud. The vapor can cause asphyxiation and is flammable in concentrations in air between 5 and 15 percent.

These standards cover LNG facilities used to liquefy natural or synthetic gas or to transfer, store, or vaporize LNG in conjunction with the transportation of gas by pipeline in or affecting interstate or foreign commerce. Part 193 prescribes an acceptable level of public safety considering the hazards of LNG and the potential causes and consequences of accidents and the steps that may be taken to safeguard against them. Part 193 provides for employee safety only to the extent that it is affected by measures required for public safety.

Background

The existing Federal safety standards governing LNG facilities used in the transportation of natural gas by pipeline are contained in § 192.12 of Title 49 of the Code of Federal Regulations. These standards were adopted by Amendment 192-10, issued on October 10, 1972 (37 FR 21638). The amendment adopted as the Federal LNG safety standards the National Fire Protection Association (NFPA) Standard 59A (1971 edition), as well as the other applicable requirements of Part 192. Subsequently, the 1972 edition of NFPA 59A was adopted (41 FR 13590).

In the preamble of Amendment 192-10, it was stated that the NFPA standard was adopted only as an interim measure while federally developed regulations specifically applicable to LNG facilities were being developed. MTB believes that there is a need for federally developed regulations for LNG facilities because the present referenced standards are not written in enforceable terms and do not adequately cover all safety problems respecting an LNG facility.

The need for comprehensive new Federal LNG facility safety standards arises because of the seriousness of potential hazards from LNG facilities coupled with the anticipated increase of LNG facility construction to meet the nation's energy needs, and the developing variations in the design of facilities near population centers, or areas of greatest energy demand. The Congress, the General Accounting Office; the Federal Energy Regulatory Commission and other Federal, State, and local agencies; nongovernment organizations; representatives of industry; and the public in general have expressed concern over the adequacy of present referenced standards to provide for public safety.

The extent of congressional concern regarding the inadequacy of the present standards and the need for the government to issue expeditiously federally developed LNG regulations is evidenced by the recent amendments to the Natural Gas Pipeline Safety Act of 1968 (the Act) under Pub. L. 96-129 (November 30, 1979). Under those amendments, the Department is now required to establish expeditiously regulations for the siting, design, construction, initial inspection, and initial testing of any new LNG facility.

A report issued on July 31, 1978, by the General Accounting Office titled "Liquefied Energy Gases" (EMD 78-28) highlights some of the safety concerns in the transportation and storage of LNG. Foremost among these are (1) protection of persons and property near an LNG facility from thermal radiation (heat) caused by ignition of a major spill of LNG, (2) protection of persons and property near an LNG facility from dispersion and delayed ignition of a natural gas cloud arising from a major spill of LNG, and (3) reduction of the potential for a catastrophic spill of LNG.

In 1974, the Department's Office of Pipeline Safety contracted for a study by Arthur D. Little, Inc., (ADL) to provide safety information on LNG facilities. The ADL report, titled "Technology and Current Practices for Processing, Transferring, and Storing Liquefied Natural Gas," included a comparative analysis of national, State, local, industrial, and professional society codes, standards, practices, and regulations relating to LNG facilities. Copies of the report (NTIS No. PB-241048) are available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22151, telephone (703) 557-4650, in paper for $7.75 and in microfiche for $3.00. A copy is also available for review in the docket.

The study identified and analyzed many areas of public concern about the operation of LNG facilities. It also addressed many practices and functions where special precautions are needed to protect persons and property. MTB believes that the results of the ADL study are consistent with current information obtained from other sources. The ADL report found that NFPA 59A was the basis for practically all national, State, and local codes for LNG facilities. MTB agrees with this conclusion and has used the NFPA 59A, in part, as a basis for these proposed regulations.

Regulatory Proceeding

In April 1977, MTB issued an Advance Notice of Proposed Rulemaking (ANPRM) (42 FR 20776, April 21, 1977) inviting public participation at an early stage in the rulemaking process for adoption of new Federal safety standards in 49 CFR Part 193. The ANPRM contained a comprehensive set of draft regulations which were intended to serve as a basis for public comment and participation in identification of LNG safety problems and the development of appropriate regulatory solutions to these problems, considering all reasonable alternatives. Subsequently, a correction was published at 42 FR 24758; and a third notice (42 FR 42235, August 22, 1978) extended the comment period to December 1, 1978, and set forth a bibliography of resource information.

Comments were solicited on safety problems and on environmental and economic issues; and persons were asked to support their comments with rationale and documentation, and where appropriate, to propose alternative regulations that would provide an acceptable level of safety. MTB also encouraged comments on the annual and aggregate costs, benefits, and other anticipated impacts associated with each of the draft regulations and all alternatives which commenters might suggest.

Comments were received on the ANPRM from 135 different commenters. Most of the comments were from industry associations or LNG operators, but a few government agencies, nonindustry-related organizations, and individuals also commented. These comments were reviewed in preparing a notice of proposed rulemaking (NPRM).

In February 1979, MTB issued an NPRM (44 FR 8142, February 8, 1979) based on Subparts A through K of the ANPRM, together with a Draft Evaluation of the costs, benefits, and other impacts associated with the proposed rules. These subparts provided a broad coverage of closely related proposed standards for the siting, design, and construction of new facilities and parts of existing facilities that are replaced, relocated, or significantly altered. They formed the basis for this final rule. While no conflicts or inconsistencies are expected between these final rules and future rules to be included in Part 193 on operation, maintenance, security, and fire protection, if any such inconsistencies are discovered as a result of the NPRM recently issued on those subjects, they will be resolved in that proceeding before final rules are added to Part 193.

Comments were received on the NPRM from about 100 different commenters. Similar to the comments received on the ANPRM, most of the comments were from industry associations or LNG operators, but government agencies, nonindustry-related organizations, and individuals also commented.

Several commenters to the NPRM reiterated positions taken on the ANPRM, especially with regard to the present referenced NFPA 59A standards. They argued that MTB should continue to adopt the NFPA 59A standards as the Federal standards because the LNG industry has an enviable safety record using these standards. The MTB is still not persuaded by this argument and continues to see the need for development of new, more stringent Federal safety standards for LNG facilities. As set forth in the preamble to the NPRM, the hazard from a catastrophic spill of LNG is very significant as shown by the spill of LNG in Cleveland on October 20, 1944, that killed 130 persons and injured 225 more. In addition, the leak of LNG in the facility in Cove Point, Maryland, on October 6, 1979, that killed one person and injured another person could have had more catastrophic effects. Also, of primary consideration in MTB's not continuing to rely solely on the NFPA 59A standards as the Federal standards is the recent amendment to the Act requiring the establishment of Federal LNG facility standards. Research conducted by various government agencies and industry groups on thermal radiation and vapor cloud dispersion has also clearly indicated the significant potential hazards that would occur if LNG escapes. Also, as indicated in the NPRM and the A. D. Little study, MTB has identified many deficiencies in the current standards which should be corrected to mitigate the potential for a major spill of LNG and provide an acceptable level of safety. Nevertheless, MTB has adopted portions of NFPA 59A to the extent appropriate. However, because of the difference in format and the need for regulatory language to facilitate enforcement, only a few sections of NFPA 59A have been incorporated by reference in the regulations as presented in the 59A Code, while other sections of NFPA 59A have been restated for their adoption as Part 193 sections.

The NFPA 59A has recently been updated by a 1979 edition that significantly strengthens many of the siting, design, and construction standards. This edition has been adopted as the referenced edition for the sections of the 59A Code incorporated by reference in the Part 193 regulations.

In response to many commenters to the NPRM, MTB has in a few cases established different standards for LNG facilities of small size having a capacity of 70,000 gallons or less. The MTB visited one manufacturer of small LNG storage tanks used in satellite facilities to discuss the need for different standards for small facilities. Because of the small size of such tanks, some standards are not necessary for such tanks. In addition, such tanks are normally shop fabricated subject to rigid quality control. The MTB has also recognized the need for continuing technological development of LNG facilities by not being overly rigid and permitting alternative compliance approaches for specific safety problems. The MTB has generally stated the proposed requirements in performance terms, using specific requirements where deemed necessary, and also referencing several industry consensus standards where appropriate.

Part 193 is adopted under the Natural Gas Pipeline Safety Act of 1968, as amended by Pub. L. 96-129. While almost all existing or planned LNG facilities involve the supply or delivery of natural gas by pipeline, it may be necessary in the future to broaden the scope of these regulations to cover LNG facilities which are not used in the pipeline transportation of gas.

Although the recordkeeping requirements proposed in the NPRM (§ 193.219 and 193.1037) have been incorporated in this final rule (§ 193.2119 and § 193.2329), the effective date of those requirements is deferred ending their coordination and clearance by the Office of Management and Budget (OMB) under the Federal Reports Act of 1946. Similarly, MTB is deferring the effective date of provisions of standards incorporated by reference in this final rule which call for the keeping of records. After completion of the OMB coordination and clearance process, MTB will publish notice of the date any given recordkeeping requirement becomes effective.

Coordination with the U.S. Coast Guard

The U.S. Coast Guard (USCG) and MTB executed a Memorandum of Understanding (MOU) with respect to a division of regulatory responsibilities for waterfront LNG facilities adjoining the navigable waters of the United States. This MOU, which became effective on February 7, 1978, was published in the Federal Register on July 14, 1978, (43 FR 30381) and again on February 8, 1979, as part of MTB's NPRM for this final rule. Under the MOU, the USCG is responsible for developing waterfront facility regulations with respect to fire protection, fire prevention, security, and all other matters between the vessel and the last manifold (or valve) immediately before the receiving tank. The USCG is concurrently developing regulations for the storage and handling of hazardous materials, including LNG, at waterfront facilities. On April 10, 1978, USCG issued an ANPRM on General Waterfront Facilities Requirements (43 FR 15107), and on August 3, 1978, issued an ANPRM on Waterfront LNG Facilities Requirements (43 FR 34362). In accordance with the MOU, MTB and USCG are coordinating their regulatory activities in this area to preclude problems involving overlapping jurisdiction. The scope of Part 193 (§ 193.2001) has been written to reflect the MOU's jurisdictional delineations regarding all matters between a vessel and tank, and matters relating to security and fire protection will be covered separately in final rules on those topics.

This final rule does not identify which waterfront LNG facilities are subject to the regulatory authority of USCG under the MOU, nor does this final rule use the term "waterfront LNG facilities." Nonetheless, all LNG facilities, whether at waterfronts or not, are subject to the authority of the Department of Transportation. The applicability of USCG's or MTB's exercise of that authority with respect to security and fire protection at waterfront facilities will be resolved in the rulemakings being pursued by those agencies regarding the operation and maintenance of LNG facilities. While MTB's February 1979 NPRM on the siting, design, and construction of LNG facilities and USCG's ANPRM on waterfront LNG facilities proposed a definition of "waterfront LNG facility," the comments received on that definition have prompted MTB and USCG to seek public comment on a revised definition. The MTB has proposed the revised definition of "waterfront LNG facility" in its NPRM on LNG facility operation and maintenance. The USCG will propose the same definition in an NPRM on waterfront facilities to be issued shortly. This future USCG NPRM on LNG waterfront facilities will also propose identical standards for fire prevention, fire protection, and security standards, as well as operations and maintenance (except where differences are warranted because of waterfront facility characteristics) to the standards proposed in MTB's operation and maintenance notice.

These final regulations are in a format consistent with that planned to be used by USCG in its pending NPRM that covers all waterfront facilities. Using this format in Part 193 will facilitate use of Part 193 and the pending USCG regulations by the regulated industry. Most of the sections in these final rules essentially follow in order similar sections in the February 1979 NPRM, but are identified by a new numbering system. The subpart headings used in the February 1979 NPRM of this regulatory proceeding are used as subheadings under the new revised subparts. The following table shows the relation between the section numbers in the February 1979 NPRM and the section numbers in this final rule.

Final rule	NPRM	Section title
193.2001	193.1	Scope.
.2003	.2	Semisolid Facilities.
.2005	.3	Applicability.
.2007	.5	Definitions.
.2009	.7	Rules of Regulatory Construction.
.2011	.10	Reporting.
.2013	.11	Incorporation by reference.
.2015	....	Petitions for finding or approval.
193.2051	.101	Scope.
.2055	.105	General.
.2057	.107	Thermal Radiation Protection.
.2059	.109	Flammable Vapor/Gas Dispersion Protection.
.2061	.111	Seismic Investigation and Design.
.2063	.113	Flooding.
.2065	.115	Soil Characteristics.
.2067	.117	Wind Forces.
.2069	.119	Other Severe Weather and Natural Conditions.
.2071	.121	Adjacent Activities.
.2073	.123	Separation of Components,
193.2101	193.201/193.301/193.401/193.501/193.601	Scope.
.2103	.203	General.
.2105	.205	Extreme Temperatures, Normal Operations.
.2107	.207	Extreme Temperatures, Emergency Conditions.
.2109	.209	Insulation.
.2111	.211	Cold Boxes.
.2113	.213	Piping.
.2115	.215	Concrete Subject to Cryogenic Temperatures.
.2117	.217	Combustible Materials.
.2119	.219	Records.
.2101	.301	Scope.
.2121	.303	General.
.2703	.304	Personnel.
.2123	.305	Valves.
.2125	.917	Automatic Shutoff Valves.
.2127	.307	Piping.
.2129	.309	Piping Attachments and Supports.
.2131	.311	Building Design.
.2133	.313	Buildings, Ventilation.
.2135	.317	Expansion or Contraction,
.2137	.319	Frost Heave.
.2139	.321	Ice and Snow.
.2141	.323	Electrical Systems.
.2143	.325	Lightning.
.2145	.327	Boiler and Pressure Vessels.
.2147	.329	Combustion Engines and Turbines.
.2149	.403	Impoundment Required.
.2151	.405	General Design Characteristics.
.2153	.407	Classes of Impounding Systems.
.2155	.409	Structural Requirements.
.2157	.410	Coatings and Coverings.
.2159	.413	Floors.
.2161	.415	Dikes, General.
.2163	.417	Vapor Barriers.
.2165	.419	Dike Dimensions.
.2167	.421	Covered Systems.
.2169	.423	Gas Leak Detection.
.2171	.427	Sump Basin.
.2173	.431	Water Removal.
.2175	.433	Shared Impoundment.
....	.435	Piping.
.2179	.437	Impoundment Capacity, General.
.2181	.439	Impoundment Capacity, LNG Storage Tanks.
.2183	.441	Impoundment Capacity, Equipment and Transfer Facilities.
.2185	.443	Impoundment Capacity, Parking Areas, Portable Vessels.
....	.445	Flow Capacity in Class III Impoundment Systems.
....	.447	Sump Basin, Capacity.
.2187	.503	General.
.2189	.505	Loading Forces.
.2191	.507	Stratification.
.2193	.509	Movement and Stress.
.2195	.511	Penetrations.
.2197	.513	Internal Design Pressure.
.2199	.515	External Design Pressure.
.2201	.519	Internal Temperature.
.2203	.521	Foundation.
.2205	.523	Frost Heave.
.2207	.525	Insulation, Storage Tank.
.2209	.527	Instrumentation for LNG Storage Tanks.
.2211	.529	Metal Storage Tanks.
.2213	.531	Concrete Storage Tanks.
.2215	.533	Thermal Barriers.
.2217	.535	Support Systems.
.2219	.537	Internal Piping.
.2221	.539	Marking.
.2223	.603	General.
....	.605	Emergency Shutdown Control System.
.2227	.607	Backflow.
.2439	.609	Overfilling.
.2229	.611	Cargo Transfer Systems.
.2231	.615	Cargo Transfer Area.
.2233	.617	Shutoff valves.
193.2301	193.1001	Scope.
.2303	.1002	Construction Acceptance
.2305	.1009	Qualification of Personnel.
.2307	.1011	Inspection.
.2309	.1014	Inspection and Testing Methods.
.2311	.1015	Cleanup.
.2313	.1017	Pipe Welding.
.2315	.1019	Piping Connections.
.2317	.1023	Retesting.
.2319	.1025	Strength Tests.
.2321	.1027	Nondestructive tests.
.2323	.1029	Leak Tests.
.2325	.1031	Testing Control Systems.
.2327	.1033	Storage Tank Tests.
.2329	.1037	Construction Records.
.2439	.919	Emergency Shutdown Control Systems.
.2441	.921	Control Center.
.2443	.925	Failsafe Control.
.2445	.927	Sources of Power
193.2401	193.701/193.801/193.901	Scope.
.2403	.703	General.
.2405	.705	Vaporizer Design.
.2407	.711	Operational Control
.2409	.713	Shutoff Valves.
.2411	.715	Relief Devices.
.2413	.719	Combustion Air Intakes.
.2415	.803	General.
.2417	.805	Incoming Gas.
.2419	.809	Backflow.
.2421	.811	Cold Boxes.
.2423	.813	Air in Gas.
.2427	.903	General.
.2429	.905	Relief Devices.
.2431	.907	Vents.
.2433	.909	Sensing Devices
.2435	.911	Warning Devices.
.2437	.915	Pump and Compressor Control.
.2439	.919	
.2445	.921	
	.925	
	.927	
193.2701	....	Scope.
.2703	.304	Design and Fabrication.
.2705	.1009	Construction, Installation, Inspection and Testing.

Final Evaluation Review

The Department has a Final Evaluation available in the Docket regarding an impact analysis of the costs and benefits of alternative potential regulations affecting the siting, design, and construction of new liquefied natural gas facilities. For this Final Evaluation, the NFPA Standard 59A (1975 edition) was used as the baseline regulatory standard against which the incremental facility costs, safety benefits, employment, environmental effects, and effects on consumers of these final regulations were measured. The other alternative potential regulations evaluated were: (a) Recommendations made in the General Accounting Office Report EMD-78-28, and (b) the Advance Notice of Proposed Rulemaking issued by MTB on April 21, 1977.

The Final Evaluation indicates that a wide range of benefits are associated with reducing or minimizing several types of potential LNG facility accidents. These benefits may range from saving several lives and injuries and preventing, or otherwise avoiding, an aggregate of $1.5 million in damage which would be incurred with a 10 cubic meter spill of LNG as a remotely located satellite facility, to saving several thousand lives and injuries, and preventing several billion dollars damage associated with minimizing the possibility of a catastrophic spill and ignition of a large LNG storage facility in a densely populated area.

Despite the very large savings that would result from preventing a major accident at an LNG facility, costly measures which reduce the likelihood of accidents are not justified by conventional theoretical cost benefit analysis because of the extremely low probability of a major accident occurring. The limited number of LNG facility accidents requires that probability estimates of accidents be based on theoretical analysis of factors which might lead to their occurrence. There is large inherent uncertainty associated with such estimates, and hence of cost-benefit values derived from them. In light of such uncertainties, prudence dictates an extra measure of caution where there is potential for a catastrophic accident. Such caution should be weighed along with other considerations when judging the need for safety measures that can reduce the likelihood of a catastrophic LNG accident, even when these measures may not be justified based on a theoretical risk analysis technique.

When compared to the baseline regulatory standard, the regulations contain eight sections which have been determined to have a major incremental cost (or more than $50,000 per section) with only minor benefits because of the low probability of the occurrence of an accident: § 193.2057, Thermal Radiation Protection; § 193.2059, Flammable Vapor Gas Dispersion Protection; § 193.2061, Seismic Investigation and Design; § 193.2063, Flooding; § 193.2067, Wind Forces; § 193.2169, Gas Leak Detection; § 193.2195, Penetrations; and § 193.2321, Nondestructive Tests.

The eight costly sections will add an average annual cost of from $200,000 to $1.1 million to the cost of a facility, depending on the types of facilities built. For the entire regulation (all sections) annualized costs per facility will be increased to from $270,000 to $1.4 million per year. This additional cost is over and above that for a facility built to the baseline regulatory standard prescribed in NFPA-59A (1975 edition). It should be recognized that many facilities would be built to a higher standard that that of NFPA-59A (1975 edition), so the above costs represent an upper limit on costs imposed by these sections.

Total annualized costs of these final rules, to build from 6 to 64 facilities, including the eight costly sections, as measured against the baseline regulatory standard, NFPA-59A (1975 edition) range from $8.4 million to $17.4 million yearly over a 20-year period.

The Final Evaluation also includes a comparison of the cost of these final rules with the recently published current edition of NFPA-59A (1979 edition), in which the total annualized costs range from $6.2 million to $12.4 million.

Considering the uncertainties inherent in risk analysis, the cost of these additional safety measures is not extreme, and the potential for the possible loss of thousands of lives and billions of dollars of property damage in the event of a major accident, MTB believes that a cost/benefit conclusion based on risk assessment alone should not be the exclusive determinant of what is necessary for public safety. The regulations are intended to prevent a catastrophic spill and the possible loss of thousands of lives and several billion dollars of property damage that might otherwise occur in a populated area.

After a careful review of the benefits, the annualized costs, and the uncertainties in predicting accident risks, MTB believes that the benefits outweigh the costs and that these eight sections are warranted as an investment in public safety.

These eight sections essentially parallel the views of the Technical Pipeline Safety Standards Committee (TPSSC) which provided MTB valuable technical assistance. A further discussion of the costs and benefits of the costly sections is discussed hereafter in the discussion related to those sections.

Discussion of Regulations

In accordance with Section 4 of the Act, the TPSSC met in Boston, Massachusetts, on June 12-15, 1979, to review the technical feasibility, reasonableness, and practicability of the regulations proposed in the NPRM. A copy of their report and minority views are available in the docket and may be obtained by writing to the Docket Branch, Materials Transportation Bureau, 400 Seventh Street, SW., Washington, D.C. 20590. A discussion of any rejections of the views of the TPSSC takes place hereafter in the discussion related to those particular sections of these final rules.

Using the new section numbers, the following portion of the preamble discusses the comments made to each particular section in the NPRM, as well as any revisions made to those proposed standards.

Subpart A—General

This subpart sets forth the applicability and other general features of the standards, and defines the types of LNG facilities subject to Part 193. The applicability of Part 193 as it relates to new and existing facilities is prescribed, and special terms or terms not used in the ordinary sense are defined. Regulatory expressions and the application and availability of referenced documents are explained. Also, the requirement to report leaks and spills at LNG facilities in accordance with Part 191 is clarified.

Scope of part. Jurisdictional aspects pertaining to waterfront facilities elicited the most response to the "Scope of part" § 193.2001. Many commenters proposed that the MOU between USCG and MTB be directly referenced. Some further advocated that the language in the MOU be included. The modifications were proposed because of a concern that failure to include all matters covered by the MOU might result in misunderstanding about the respective areas of responsibility.

As discussed previously, USCG is developing regulations to provide standards for safety, security, and environmental protection in the transportation, transfer, handling, and storage of liquefied natural gas at waterfront facilities. It intends for these regulations to become an integral part of its revised general waterfront facility regulations. MTB and USCG are coordinating their regulatory activities in this area to preclude problems involving overlapping jurisdiction in consonance with the MOU.

Specifically, at a waterfront facility, under the MOU, the USCG is responsible for facility site selection as it relates to management of vessel traffic in and around the facility; fire prevention and fire protection equipment, systems, and methods for use at a facility; security of a facility; and all other matters pertaining to the facility between the vessel and the last manifold (or valve) immediately before the receiving tanks.

Conversely, MTB is responsible under the MOU with USCG for facility siting safety except for vessel traffic matters, and all other matters pertaining to the facility beyond (and including) the last manifold (or valve) immediately before the receiving tanks, except for those matters pertaining to fire prevention and protection, and to facility security.

In response to these objections regarding the definition of "waterfront LNG facility," the term has been deleted in § 193.2001. Appropriate delineation of the limits of MTB's responsibilities under the MOU over fire protection and security will be set forth in the scope of those topics in MTB's rulemaking covering operation and maintenance of LNG facilities.

Several commenters also proposed an addition to § 193.2001(b) exempting tanks with a capacity of 70,000 gallons or less. In some instances, the exemption was recommended only if the aggregate capacity would not exceed 140,000 gallons. The commenters felt such a proposal could be justified because tanks having a capacity up to 70,000 gallons can be shop fabricated, making this size subject to greater quality control. Also, the commenters argued that NFPA 59A was more appropriate for small containers.

The MTB has recognized the need for establishing appropriate regulations which would take into consideration the wide difference in size, type, and characteristics of LNG facilities. As a consequence, care has been taken in a number of instances, modifying requirements according to the size and type of a facility, so as not to be overly burdensome to a small plant. For example, § 193.2061, "Seismic investigation and design," includes provisions that greatly reduce the stringency of requirements for facilities of the size range suggested by commenters. In other standards, requirements vary according to either the extent of the hazard or facility size. This feature is exemplified by the exclusion zones required for thermal radiation and vapor dispersion whereby the exclusion distance would depend on size and characteristics of the facility, and by requirements for separation of facilities which are dependent on size.

The MTB has not adopted the recommendations to exempt tanks not exceeding 70,000 gallons capacity from the applicability of Part 193, since spills, even from small tanks, could also result in significant hazards.

A few commenters strongly recommended that the term "minimum standards" be used in lieu of "standards" so that it is clear that the standards may be exceeded, and to be in accord with the language of the Natural Gas Pipeline Safety Act of 1968. This proposal has not been adopted because such a term appears to imply that the standards are marginally adequate and must be supplemented. Therefore, this sections remains unchanged.

In accordance with Pub. L. 96-129 amendments to the Act, structures and equipment used as LNG facilities that are located in navigable waters (as defined by 16 U.S.C. 796(8)) are no longer subject to the Act. It was the intent of Congress that such facilities be regulated under the Port and Waterways Safety Act. Therefore, a new provision is added to § 193.2001 to exempt facilities in navigable waters from the scope of Part 193. Likewise, under this provision facilities located offshore would not fall under Part 193. Section 193.2003 addresses facilities handling semisolid natural gas in accordance with another Pub. L. 96-129 amendment to the Act that extended the definition of LNG to include natural gas in a semisolid state.

Section 193.2005, covering the applicability of these final regulations, has been substantially revised in conformance with Sec. 6 of the amended Act that establishes the applicability of these regulations to existing LNG facilities. The final regulations governing the siting, design, and construction (including initial inspection and testing) of an LNG facility will not apply to LNG facilities under construction before the date of publication of these regulations or to LNG facilities for which an application for approval of the siting, construction, or operation was filed before March 1, 1978, with the Department of Energy (DOE) (or any predecessor organization of DOE) or the appropriate State or local agency in the case of any facility not subject to the jurisdiction of DOE. (The siting, design, and construction of these facilities is governed by 49 CFR 192.12.) However, any subsequent replacement, relocation, or significant alteration of such facilities must comply with Part 193 requirements for siting, design, and construction, except that the siting requirements apply only to relocation of LNG storage tanks and to any replacement or alteration of an LNG storage tank that increases the storage capacity of the original facility. It was decided not to apply the siting standards to existing facilities other than storage tanks because of the high costs and impacts involved with facilities of lesser safety significance. This limitation of the applicability of siting requirements to existing facilities is consistent with the new provisions of Section 6 of the Act which precludes the imposition of siting standards on replacements made at certain existing facilities. The MTB does not consider replacements to include construction that results in increased storage capacity. Such construction as well as movement of a tank to a new site is more akin to construction of a new facility to which Congress intended the new rules to apply. In addition, again consistent with Section 6 of the Act, any subsequent relocation, replacement, or significant alteration of existing facilities could be designed, installed, or constructed in accordance with the original specifications or an alternative manner found acceptable by the Director, if Part 193 design, installation, and construction requirements would make the replaced, relocated, or altered facility incompatible with other facilities or would be impracticable.

Definitions. Changes to various definitions in § 193.2007 were recommended by many commenters. Definitions for additional terms were also proposed. Only words not used in the ordinary dictionary sense and words that are necessary to apply the rules are defined. Some words have been deleted as a result of changes in the text of the rules. Revisions with appropriate editorial modifications have been made as a result of changes in the text; in response to comments; to clarify the meaning; or otherwise, to make the definition more concise. Although there has been no change in the meaning intended, the definition of "cargo transfer system" has been changed in order to define the term independently from connected "transfer piping." It has also been made more concise by eliminating unnecessary verbiage, and the term "associated area" has been deleted in accordance with comments from the TPSSC. Where area is relevant to compliance, the term is used in the final rules.

The term "critical component" has been deleted. The TPSSC, as well as most commenters, stated that the term was not clearly defined and not distinguishable from the word "component." These regulations now use the term "component" and, in some cases, general descriptive terminology refers to the specific components that may be more hazardous. The term "critical process" has also been deleted because it appears unnecessary.

In accordance with the views of the TPSSC and other comments, which requested deletion of the term "impermeable" from the definition of the word "dike," MTB has deleted the term together with other terms that are design features since such provisions are more appropriately covered by design standards.

Many commenters, together with the TPSSC, objected to the proposed definition of "hazardous fluid." In the

NPRM, "hazardous fluid" was defined by reference to Parts 172 and 173 of 49 CFR which include many materials that would not be hazardous in an LNG facility. Commenters felt that a "hazardous fluid" should be defined only as a flammable gas or liquid. The MTB has included toxicity also as a measure of safety since minute quantities could be injurious to the public, or if plant operators are affected, an unsafe operating condition could result.

A definition for "hazardous liquid" has been added since it is used both in the definition of "hazardous fluid" and in the body of the text. The TPSSC had suggested that the term be defined as "a hazardous fluid in the liquid state." However, the final definitions appear to be clear and more concise.

Objections to the definition of "LNG facility" were primarily based on uncertainty about the delineation between LNG facilities and other gas pipeline facilities. Accordingly, the term has been revised. The new definition identifies facilities dedicated to LNG by utilizing the definition of "pipeline facility" in the Act to describe the nature of facilities that are included. It is important to note that "pipeline facility" is used to define the term "LNG facility" in accordance with Pub. L. 96-129 amendments to the Act, so that the term "LNG facility" applies to any part of an overall related series of facilities used for the transportation or storage of LNG, or for conversion (liquefaction, solidification, or vaporization) of LNG. An entire series of related LNG facilities is defined as an "LNG plant."

The term "maximum allowable operating pressure" (MAOP) has been changed to "maximum allowable working pressure" (MAWP). The TPSSC, along with some commenters, objected to the definition of MAOP because no basis for determination was set forth in the design portion of Part 193. Some commenters felt the term should be changed to "maximum allowable working pressure" (MAWP) or defined in accordance with consensus standards. The MTB had recognized the potential difficulties in establishing MAOP for this part in the manner used by Part 192 as a result of the design portion and operating portion of Part 193 being issued separately. In veiw of this, and because MAWP is a more appropriate term for plant type facilities, MTB has used the term "maximum allowable working pressure" in the text of the regulations consistent with the use of the term in the referenced design codes.

Although the intent of "normal operation" remains essentially the same, it has been made more concise by describing "other criteria" as that "required by this part." This change essentially is in accord with the recommendations by the TPSSC and some commenters. In effect, as long as a facility is performing within the prescribed criteria of Part 193, its operation may be considered to be normal, thereby giving a broader understanding of the term.

The definition of the term "transfer piping" is changed to refer to a system of piping and not to individual components in such a system. Also, the phrase "and associated area" is deleted in accordance with a recommendation from the TPSSC, because there is no general need for it in the standards, and it is not physically a part of the piping. Where appropriate, it has been incorporated in the applicable section. The word "supports" has been eliminated also, and treated separately where appropriate in the section concerned. In addition, the definition has been revised to resolve potential difficulties with the term "containers" by designating the individual components that describe the limits of transfer piping. In this respect, the term "other than pipeline facilities" pertains to facilities such as those that might use LNG for cryogenic purposes, such as freezing, in a process not involving the transportation of gas.

Reporting. One comment advised that the extent of "leaks and spills" as used in § 193.2011 should be described. The MTB feels this is unnecessary, since the operator must report leaks and spills in accordance with the requirements prescribed in 49 CFR Part 191. However, MTB recognizes that LNG facilities are not effectively covered by the present reporting forms under Part 191, so MTB plans to develop reporting forms appropriate for LNG facilities. MTB is also contemplating establishing reporting requirements for abnormal operations, which could serve as a source of information for the design of new LNG facilities. Until new forms are developed, however, information applicable to leaks or spills of gas or LNG at LNG facilities must be reported to the maximum extent possible on the existing forms prescribed by Part 191.

Incorporation by reference. With respect to § 193.2013, one commenter proposed that wording be changed to reference editions that are current at the time of plant design because MTB has not routinely updated the editions of incorporated documents. Only current editions, it was said, reflect the consensus of the originating organizations and establish "good engineering practice."

The MTB has not adopted this recommendation, because it would be both an abrogation of responsibility by MTB and contrary to the Administrative Procedures Act and implementing regulations of the Federal Register. Documents referenced in Part 193 are set out in Appendix A and the applicable edition is referenced. Later published editions will be reviewed by MTB and, if warranted, proposed for inclusion in Appendix A as part of our current program for keeping referenced documents up to date.

Subpart B—Site Related Design Requirements

The criteria for site related design requirements that must be considered in the planning and selection of a site are set forth in this section. Also, provisions to assure that the site will have accessibility and sufficient size for mobility around components in the event of an emergency are included. Public response to the notice on this subpart was more extensive than for all other subparts combined.

Scope. Only nine commenters responded to § 193.2051 in the notice. These comments were used in formulating the "Applicability" section in Subpart A. The extent to which siting requirements would be imposed on replacements and alterations of existing facilities was the major issue. Some commenters proposed that, for existing facilities, the Subpart B siting requirements be applied only to actions that result in an increase in LNG storage capacity. Others argued that safety improvements would be inhibited if modifications or repairs had to comply with siting requirements and emphasized the need for flexibility to permit repairs and modifications.

To illustrate the commenters' objections, studies relating to thermal radiation, vapor dispersion, seismicity, and other site-related features were viewed as unreasonable for the replacement of components. Such studies were viewed as appropriate for existing facilities only where either an expansion in LNG storage or relocation of an existing facility to a new site is involved.

As reflected in § 193.2005, after much deliberation, MTB determined that the applicability of site related requirements to replacements of existing facilities should be limited to replacements that increase storage capacity. Considering the greater cost expected for compliance with site-related requirements at existing facilities, safety would be best served where new standards are made to apply to conditions that impose the greatest potential hazards. This position also appeared to be in general accord with the public comments. However, the Pipeline Safety Act of 1979 (Pub. L. 96-129) makes this matter, and the alleged conflict with the 1968 Act regarding existing facilities, somewhat of a moot issue. Consistent with the Act, as amended by Pub. L. 96-129, and as set forth in § 193.2005, Applicability, replacements of an existing facility would be exempt from the siting standards if application for approval was filed with appropriate Federal or local agencies before March 1, 1978. This exemption policy also is applied to all LNG facilities under construction before Part 193 is published.

Objections to use of the term "critical component" in the scope section were expressed also. In particular, the objection by the TPSSC "concerns the applicability to existing critical components which are not clearly defined." As discussed earlier, the term has been deleted.

This section lists the components or LNG facilities to which this subpart applies. The list of components which was set forth in § 193.111 and § 193.113 in the NPRM has now been incorporated in § 193.2051 to apply to all sections in this subpart and has been revised in accordance with a few comments. Those comments argued that only "emergency shutdown control systems" should be included because there are many "shutdown control systems" that are not critically important to the safe operation of an LNG facility during the occurrence of an earthquake. In addition, as proposed by these same commenters, the fire control system should be designed to withstand an earthquake because an operable fire control system is essential to the safety of an LNG facility during an earthquake.

Acceptable site. Consistent with views expressed previously, commenters and the TPSSC again objected to the term "critical component" in § 193.103 in the NPRM.

The use of this term has been discussed under earlier sections, and the term has been eliminated from these rules. Further, in the case of this section, it was found to be a duplication of § 193.2055, and therefore, this section has been deleted.

General. Among approximately 12 commenters who uniformly responded to sections of this subpart, about half felt that § 193.2055 as proposed in the NPRM was acceptable. This section, prescribes generally that a site must be suitable for design of leak and spill protection and ease of access. The TPSSC conditionally found this section to be feasible, reasonable, and practicable, if the words "and other hazardous liquids" are removed. Six commenters, all representing the regulated industry, objected to this term. The term "flammable refrigerants" was proposed as a replacement by five commenters. They argued that regulations should apply only to spills of liquids stored in large volumes. One commenter, however, felt that coverage should be expanded by using the term "hazardous fluids" because a large vapor leak could be dangerous.

Four of the former five also argued that the definition in the NPRM made the term "hazardous liquids" too broad. This appeared to be the reason for the TPSSC's objection.

The recommendation by the TPSSC which would subject only LNG to the regulation has not been adopted because the exemption of other hazardous fluids, potentially more hazardous under certain conditions, clearly is not in the interest of safety. Even the regulated industry did not seek exemption for hazardous liquids other than LNG.

The MTB also has rejected changing the term to "flammable refrigerants" since the exclusion of other flammable fluids, merely because they are not used as refrigerants, is clearly unjustified from a safety viewpoint. For example, where propane used as a refrigerant in the liquefaction process at a small peak-shaving plant would be subject to the regulation, it would be inconsistent to exempt possibly larger potential spills or leaks of propane at a baseload or satellite facility, simply because it is used as a fuel or heat transfer medium. Also, where the storage volumes are small, associated safety considerations normally will be subsumed by the requirements for the larger storage of LNG. Accordingly, design to minimize offsite leak and spill hazards from small storage volumes should not impose a significant burden on facility design. The MTB believes that this aspect, together with the change in definitions of hazardous liquids and fluids, will assuage concerns of these commenters, as well as the TPSSC.

The MTB believes that without adequate provisions, a large gas or vapor leak could be dangerous. For example, discharge from relief vents or stacks or damage from external causes, such as impact from falling objects to containers or piping, could present an unnecessary hazard unless location or protection is properly planned. Accordingly, MTB has adopted the proposal to assure that the site can accommodate design to mitigate hazards from leaks and spills of both LNG and "other hazardous fluids."

A change in the wording "persons and property" to either "the public" or "offsite persons and property" was proposed by six commenters. The change was needed to assure an understanding that only the offsite public and not plant personnel are referenced, according to five responding. Four of the five also argued that otherwise the intent of the NPRM "Supplementary Information" would be contradicted.

On Page 8142 of the NPRM, under "Supplementary Information," it states that, "In most cases, Part 193 would provide for employee safety only to the extent that it is affected by measures required for public safety." While such standards as exclusion zones for thermal radiation and vapor dispersion are intended to provide offsite protection, some standards such as employee training provide protection to employees as well as the offsite public. In addition, requirements for ease of access to provide for evacuation clearly apply more directly to employee safety. This is consistent with wording in the "Supplementary Information" which indicates that in some cases provisions are intended for employee safety.

Partly in accordance with the recommendation, MTB has revised the wording to "persons and offsite property" to more clearly show that, within reasonable limits, consideration should be given also to employee safety in the plant layout design.

A recommendation that the phrase "to the facility" be added after the words "ease of access" was made by four commenters. Two of these commenters argued that clarification was needed to show that a means of getting people and equipment to the facility during an emergency is required, while the other two felt the addition was important to show that facility access rather than site access is the issue. One other commenter proposed that the requirement for "ease of access" be deleted. Since the function of the access is explicitly described in the text, MTB believes the proposed addition would only serve to confuse the meaning. Accordingly, the original wording has been retained without change.

An editorial change to show more clearly that one function of the requirement for ease of access is to provide for personnel evacuation, with or without assistance from others, was made in accordance with one comment. Other comments involved exclusions based on the MOU between USCG and MTB, and objections to the word "determine." Both matters are discussed under Subpart A, and no changes are made in these respects.

Thermal radiation protection. Because of the extensive response to § 193.2057, most comments will be discussed by subsection. As a general comment, however, two commenters felt that detailed fire modeling should not be included in Part 193. Formal hearings, they argued, would assure acceptable design, and therefore, only flux levels, prescribed in performance language, should be set forth in this section. While formal hearings have not been established, flux levels are prescribed in the last subsection, and use of the model proposed in the NPRM has been deleted.

The format of § 193.2057(a) has been set forth in two parts, (a)(1) and (a)(2), for clarity. With respect to (a)(2), three commenters advocated that the requirement for grading and drainage to be treated as an impounding space be deleted. Most commenters, however, appeared to find the provision acceptable. Essentially, the various reasons for the opposition were that: the spill amount and fire duration will be small because of automatic shutdown; thermal radiation hazards would be minimal; grading and drainage is most appropriate near boundaries; spill disposal by grading and drainage would meet the requirements; an operator choosing to design more protection (by grading and drainage) would be penalized.

Within an exclusion zone, the exposure time to reach limits of human tolerance to heat radiation from a fire are very short. Therefore, even if the period of the fire and thermal radiation is short, the public would be subject to potential harm or injury. Additional protection distance is also needed where grading and drainage or other impoundment for small spills is located near boundaries. In most instances, the exclusion zone required for major impounding systems could extend beyond zones needed for small spills. Therefore, with a well engineered layout, there would be minimal or no additional cost to provide a thermal exclusion zone for grading and drainage. However, if additional protection is needed, even for small spills, the distance must be provided. Accordingly, MTB has retained this regulation.

Deletion of § 193.2057(b), "Measurement of exclusion zone," was proposed indirectly as a result of alternate proposals by seven commenters. One commenter proposed a "spherical" model which will be discussed further under paragraph (c) of this section. If adopted, this paragraph would not apply because the model was based on a different geometry of measurement. However, this model excluded wind effect on the fire pattern (tilt) which was said to be offset by the cooling effect of wind on the target. Considering the lack of precision in modeling thermal radiation, this model appears to have much merit, particularly for application in safety standards. However, since it was verified only by correlation with another more complex model, rather than with test data and it did not provide a method of measurement which could account for topographical variations, this comment was not adopted.

The six other commenters would replace this paragraph by the use of performance language and public hearings, by performance language in conjunction with the simple point source equation of the form d=(f) V A, or by the simple point source equation without prescribing a method of measurement to account for the geometry of the fire pattern relative to the target. Aspects of some of these proposals have been adopted and will be discussed under the appropriate subsections. However, the method of measurement set forth in paragraph (b), with some modification, has been retained in order to assure a uniform method of measurement which includes some provisions for wind effects and geometry of the fire relative to the target.

One other commenter recommended only that the diagram in this paragraph be deleted, arguing that because the method does not consider flame height, structures at higher elevations would be subject to higher thermal flux since the flame would rise. This apparently is a misunderstanding, since the diagram is intended to account specifically for the target elevation and the relative geometry due to flame height and other parameters.

Modification of the diagram to show that calculations are correct was also suggested. This was said by one commenter to be needed in order to assure accurate calculations. While the diagram does not show a sample exclusion zone, samples of the exclusion distance "d," which defines the boundary of an exclusion, are depicted. An elevation view, which cannot illustrate the exclusion zone, is necessary to explain the method of measurement and thereby assure that calculations will be accurate. Consequently, this suggestion has not been adopted. However, the diagram has been modified in accordance with certain comments, changes in other paragraphs, and to better assure a correct understanding.

Also relating to the diagram, a recommendation to locate point (T) at the edge rather than the center of a target was made by one commenter. This location was said to be more appropriate to define exclusion zones, particularly because targets may be very large. The MTB intended for point (T) to be a point on the target closest to point (P) and has modified both the diagram and the language accordingly.

According to one commenter, a third point to identify geometric planes referenced in the diagram was said to be necessary because three or more points are necessary to identify such planes. The plane in question was referenced in the final rule to describe (PT) and (PD). Where a plane is unbounded and described as vertical, it may be specially described by two points only. The reference has been deleted in the rule because it was used only to clarify and is unnecessary. However, these latter two comments bring attention to a possible ambiguity in the NPRM diagram, which does not give an upper limit to the angular elevation of line (PT). As a result, incident flux might have exceeded the intended level since (PT) was free to rotate around an axis through (P) and orthogonal with the vertical plane (of the NPRM). Thus, a high structure could theoretically be positioned above the thermal envelope. The MTB has been aware of the need to correct this mathematical anomaly, and the diagram has been modified by including the necessary upper limit.

The methods prescribed for determining both (θ) and (L) were an issue of major concern to several commenters. To determine (θ), an angle to account for flame tilt and potential formation of some vapor before ignition occurs, the NPRM prescribed equation G-4 in American Gas Association (AGA) report IS-3-1. Some commenters indicated preference for equation F-14 (or Thomas's equation) from the report IS-3-1, arguing that it is more realistic and predicts less tilt except at lower wind speeds, or that equation F-14 should be used for an emissive flux of 45,000 BTU/ft.^{2} hour. One commenter submitted comparative data illustrating the wide divergence between flame tilt determined by an IS-3-1 method and his own calculations. Similarly, many recommendations were made to alter the method for determining (L), a dimension to account for flame length. The NPRM prescribed equation G-7 or G-8 from IS-3-1. Some commenters advocated the use of equation F-13 (or G-5) because it predicts that the ratio L/D will decrease as D (the flame base diameter) increases, while G-7 and G-8 predict the reverse and are therefore more conservative. Others argued that

F-13 should be used if an emissive flux of 45,000 BTU/ft.^{2} hour is prescribed. One commenter noted that F-13 represents the average rather than maximum flame length. Another commenter said that F-13 predicts (L) with reasonable accuracy if the correct boiling rate is used, and another stated that a recent report uses an L/D ratio of 3. The report doesn't mention correlations from equations in IS-3-1.

With respect to both (θ) and (L), several commenters recommended allowing the use of any of the equations given in IS-3-1. A number of commenters advocated that a specific method not be prescribed, and that the rules provide for alternate models to permit the use of improvements in technology as more is learned about emissive power, flame tilt, flame length ratio (L/D), burning rates, and other flame characteristics.

Optional use of different methodologies giving different results as recommended by some commenters is not appropriate for a standard to establish consistent and uniform levels of safety. The proposal to reference report IS-3-1 in general has not been adopted. Also, because of the uncertainties evidenced by the conflicting methods, results, and viewpoints, rigorous modeling with the information currently available is unjustified. The MTB agrees that models should permit the use of additional and more valid information when it becomes available. Accordingly, the regulation has been modified by deleting reference to any specific model and permitting the establishment of θ and L in accordance with the use of alternate models that are approved by the Director.

The MTB believes that optional fixed values of (θ) and (L) are needed in order to provide a simplified method which will assure a conservatively safe exclusion zone. Such fixed values will preclude extensive data compilation, calculation, and probabilistic determinations that could be needed otherwise. This approach is needed until more rigorous models can be verified by test. More specifically, it is intended for use when rigorous methods are unjustified because of expense or lack of wind data, and some alternative is needed. The regulation has been modified accordingly. A value of (θ)=45° for optional use is provided as originally set forth in the ANPRM. It is based on the limited data in IS-3-1, since data for fires of larger size are unavailable. Also, to a limited extent, it is intended to provide for the formation of some combustible vapor before ignition occurs. The value for (L) is based on an (L/D) ratio of 3. This is consistent with the recent report mentioned by one commenter and the unsteady state of LNG fires, particularly at the time of ignition if some vapor has formed.

Other modifications in § 193.2057(b) are made to provide greater clarity.

In consideration of the many comments about § 193.2057(c), concerning the computation of exclusion distance, this subsection has been significantly revised. With respect to paragraph (c)(1), the method of determining the assumed emissive area of the flame "A" was clearly the principal issue. Commenters argued variously that the bottom and back; the bottom and top; or the bottom, top, and half of the side area of the flame should not be included. Three commenters said "A" should be the fuel surface area, but would retain the emissive power for a flame. Two contended that the proposed determination of "A" defies the most simple concepts of physics and laws of nature. A variety of other adverse comments also were made with regard to "A".

The MTB believes that the description for "A" given in the NPRM (as corrected) is reasonable. The formula G-9 on page G—27 of the report IS-3-1 uses the total emissive power of the flame. This is determined most directly by using the product of flame surface area and emissive power per unit of flame area, since data giving the fraction of total combustion energy radiated to the surroundings is not well established. Because the model is a point source, emissive power is radiated in all directions, requiring consideration of the entire surface of the assumed flame cylinder. The MTB concedes that some question may exist about the use of the bottom of the flame cylinder. However, because thermal radiation data and predictive methods are uncertain, the entire assumed cylinder area was used to assure reasonable conservatism. For these reasons, and because of other modifications to be discussed, none of the recommendations has been adopted.

Taking an opposite position, one commenter, who recognized the familiar point source equation, expressed agreement with the logic of determining "A" according to the NPRM. Using the entire surface area of an assumed flame cylinder, "A", as the surface of a sphere, a new and simple "spherical" model was derived from the resulting geometry. Comparisons with sample results of a more sophisticated model showed relatively close correlation. Considering the range of accuracy in radiation modeling, the commenter recommended that the "spherical" model be used in place of both models (paragraph (c)(1) and (c)(2)) in the NPRM. The MTB believes the recommendation may have merit. However, the spherical model has not been correlated with actual test data. Because of this and for reasons more fully discussed under § 193.2005(b), MTB has not adopted this recommendation.

The NPRM formula in paragraph (c)(1) was also criticized by some commenters as being inconsistent with detailed sophisticated techniques or incorrect, defying the laws of nature. Others expressed the view that the formula has good far field correlation, but is inappropriate for near field application. The formula is a rearranged expression of the point source equation (G-9) from page G-27 of IS-3-1. It has the limitation of an overly simplified formula, but was considered appropriate for application as an optional simplified approach if adequate conservatism was provided, particularly in view of the uncertainties associated with thermal radiation data. However, as discussed below, it does not appear in the final rules.

The emissive flux of 45,000 BTU/ft.^{2} hour, prescribed for use with the methods of both paragraph (c)(1) and (c)(2), also was found unacceptable by a number of commenters. For the most part, objections were based on the use of a higher emissive flux level than the flux level used with the prescribed model as it appeared on IS-3-1. The flux level of 45,000 BTU/ft.^{2} hour was selected by the MTB due to the wide scatter in emissive flux data, and the lack of such data for large fires where some evidence indicates that flux could be even higher. The MTB does not agree that the prescribed flux made the model invalid. As noted by one commenter, as intended, its use merely increased the exclusion distance. However, concerns expressed are nullified, since a specific flux is not prescribed in the final rule.

The simple point source equation of the form "d"=(f)V A was recommended by a number of commenters. Two of these commenters felt this simple equation should replace the more sophisticated method in paragraph (c)(2) also. By using appropriate (f) values, this model was said to assure adequate conservatism, and to account for fire, tilt, and down wind flux increase. Its relative simplicity was viewed as a desirable feature.

Many commenters objected to the more sophisticated specific model prescribed in paragraph (c)(2) in the NPRM. In line with recommendations regarding paragraph (b), some commenters said the rule should be changed to permit the use of either model in IS-3-1. In addition, provision to permit the use of future alternate models was strongly recommended. This provision, it was reasoned, would permit use of improved technology as more is learned about thermal radiation and flame characteristics. Some contended that a specified model would limit amendments to requirements, while the elimination of a specified model would encourage further research and development.

The nature of the comments clearly illustrates that uncertainties and lack of agreement exist among commenters regarding thermal radiation modeling. The degree of precision in predictability has not been established, particularly for large fires, since there has been no verification testing in the necessary size range and scaling effects are not yet known. In consideration of these problems, MTB has adopted the recommendations of many commenters to provide for alternate models to be used as future technical data with a known degree of reliability are developed. Accordingly, § 193.2057(c)(2) provides for the use of a mathematical model to determine exclusion distance length which meets prescribed criteria and receives approval by the Director.

Also, considering the lack of reliable thermal radiation data, lack of precision, and corresponding range of differences in predictive results from current sophisticated models, the MTB has adopted the recommendation of a number of commenters to use the simple point source equation of the form $d=(f)(A)^{0.5}$, as originally proposed in the ANPRM. This equation in § 193.2057(c)(1), used in conjunction with values of (f) in paragraph (d) of this section, provides a simple means of assuring adequate protection distance for public safety until sophisticated techniques for establishing reliable thermal radiation data are developed. Also, it would continue to apply where more sophisticated techniques are unjustified.

The MTB believes these modifications agree with the intent of the TPSSC who felt the NPRM formulas were not reasonable for establishing exclusion distance and questioned the availability of the proposed model.

To establish the limiting values for incident radiant flux in § 193.2057(d), according to the characteristics of offsite targets, (f) values corresponding to prescribed flux levels have been included for use with the point source equation in paragraph (c)(1). The level of flux permissible on some targets has been also slightly modified. In the NPRM, a flux of 1,600 BTU/ft.^{2} hour was proposed as the level for human exposure in ourdoor areas. In response to the NPRM, one commenter felt the flux levels were too low, contending they were based on total, instantaneous, and immediately ignited spills. The MTB believes this argument is not valid because technical reports on this subject do not support these arguments. A reduction in the 1,600 BTU/ft.^{2} hour flux level was proposed by four commenters. The flux range of 450 to 500 BTU/ft.^{2} hour was viewed as appropriate by two commenters, based on the argument that USCG Standards (CG 446-3 Vol. III CHRIS) considers 450 BTU/ft.^{2} hour to be the safe limit for people. A copy of the referenced information was enclosed in the comment. A second enclosure from the same document gave information to show that an intensity of 1,500 BTU/ft.^{2} hour required protective clothing. The USCG, which formerly had supported higher flux levels based on NFPA 59A, now agrees with the flux levels set forth in this standard. The referenced document is not a standard, but a guide applying to indefinitely long periods of exposure and does not apply to circumstances where persons would seek shelter or depart. Some, noting that 500 BTU/ft.^{2} hour was only slightly more that thermal radiation from the sun, argued that such a low flux would be excessively costly and would permit the continuation of normal activities which could impede emergency movement. The majority commenting recommended retention of the proposed 1,600 BTU/ft.^{2} hour flux level. At that flux level, according to some comments and technical reports, exposure time for pain is 15 to 20 seconds and about 30 seconds for injury. During this period, a healthy person could increase his protection distance by 300 to 600 feet and thereby reduce the flux level and increase the allowable time of exposure. Also, clothing, partial shielding from nearby objects or topography, or altering position to change the area of the body exposed will afford additional time to move out of range or find shelter. The cooling effect of the wind will increase the time further, and if the wind speed is low, greater distance will have been provided because the distance measurement under § 193.2057(b) is based on tilt at higher wind speeds. A study by Dr. R. O. Parker concludes that thermal radiation becomes hazardous to personnel at 2,000 BTU/ft.^{2} hour, which would allow a solar level of 350 plus 1,650 BTU/ft.^{2} hour from other sources. Therefore, in consideration of the factors described and in accordance with the views of the majority of commenters, MTB believes that establishing a permissible flux level of 450 to 500 BTU/ft.^{2} hour is unjustified, and the proposed 1,600 BTU/ft.^{2} hour flux level is retained in the final rule.

Also, numerous commenters felt that the term "outdoor assembly" should be more specifically defined in describing the target. Some felt that some beach areas would present major difficulties, particularly if casual access was to be a consideration, and where the laws of some States preclude private ownership. The respective target has been redefined to areas occupied by 20 or more persons during normal use in order to be both more definitive and preclude some of the problems foreseen. Most importantly, it is made consistent with the definition of outdoor assembly established and used in Part 192.

Four commenters advocated a uniform flux level at the boundary. One who did not recommend a specific level felt it was unsound to use variable flux levels because the purchase of land may be necessary to provide for future land changes. A single uniform flux of 1,600 BTU/ft.^{2} hour was proposed by two commenters. One expressed the view that escape time is not adequate because the level of 4,000 BTU/ft.^{2} hour allows only 5 to 7 seconds before second degree burns are experienced. Shelter, it was said, could not be found in such a short time. Without giving justification, the fourth commenter proposed a single uniform flux level of 2,800 BTU/ft.^{2} hour.

The concept of single uniform flux levels has not been adopted because MTB believes the level of protection should be established according to the degree of protection needed in order that the level of safety will be uniform, and to reduce unwarranted costs. While land purchases may be necessary to provide for future change, the zoning concept in the definition of exclusion zone was specifically intended to provide relief in this regard. In addition to control by a government agency, purchased land could be put to use in various ways that conform to the regulations. Reduction in thermal radiation flux levels due to wind cooling effects, clothing, running away, etc., as discussed with respect to persons in outdoor areas, applies equally to target areas subject to a flux level of 4,000 BTU/ft.^{2} hour. Also, areas of this type would have nearby shelter, and some shelter from trees, bushes, or other structures would be likely. In addition, persons in these areas would be either sheltered indoors, or away from the area a large percentage of the time.

Several commenters proposed an increase from a flux level of 4,000 to 5,000 or 6,700 BTU/ft.^{2} hour. This was based on tests of a variety of woods showing ignition did not occur at this flux level. This recommendation would reduce exposure time to a critically low level where persons may be present or need time for escape. However, the recommendation has been adopted in part by more of a realistic categorization discussed below.

In response to a comment that the terms "frequently occupied" and "exceptional value" lack specificity and could be misinterpreted, the characteristics defining offsite target areas subject to a flux level of not more than 4,000 BTU/ft.^{2} hour have been restated. The new definition divides the proposed offsite target (2) into two parts, (2) and (3). Both categories apply to buildings. Category (2) applies to buildings based on human occupancy and clearly shows that residences are included. Also, for consistency with Part 192 and other sections of Part 193, the term "frequently occupied" is redefined as "being occupied by 20 or more persons during normal use."

In category (3), the buildings are identified according to their fire-resistant properties and their usage. The meaning of "exceptional value" has been restricted to specific historic merit. The feature of durable shielding has been added so that flux levels will be low enough to permit escape or the removal of objects if shielding for the duration of a fire is not adequate.

Conversely, a new category (4) for flux levels of 6,700 BTU/ft.^{2} hour also applies to buildings based on properties for protection from thermal radiation in conjunction with the same uses specified for category (3). The MTB solicits comments on the establishment of this flux level for this new category (4), rather than 10,000 BTU/ft.^{2} as proposed in the NPRM.

Under category (5) (formerly category (4) in the NPRM), applying to public streets, highways, and mainlines of railroads, one commenter recommended retention of the 4,000 BTU/ft.^{2} hour flux level for public streets, but proposed an increase to 10,000 BTU/ft.^{2} hour for highways and mainlines of railroads. Another commenter proposed an increase to 10,000, while a third recommended 6,700 BTU/ft.^{2} hour as the appropriate level. Two other commenters indicated that the flux level should be increased, but did not recommend a specific level. It was argued that high mobility of highways and railroads affords protection, and the ability to close transportation corridors prevents long term danger. Some said that vehicles and their speed would provide protection to the 10,000 BTU/ft.^{2} hour flux level, while one felt these conditions justified the 6,700 BTU/ft.^{2} hour thermal flux.

Although commenters disagree on the specific flux levels that are appropriate, the MTB believes the arguments presented have merit. Speed and mobility certainly afford some protection by permitting faster escape. Also, even if a flux of 6,700 BTU/ft.^{2} hour allows only 3 seconds for escape, as mentioned by one commenter, all the mitigating factors, such as cooling effects of wind discussed previously in regard to outdoor assembly, are equally applicable in this case. In addition, even the glass areas of vehicles provide some shielding. Based on these considerations, the MTB believes that an increase to an incident flux of 6,700 BTU/ft.^{2} hour is appropriate, and has modified the requirement accordingly.

Under category (6), formerly category (4) in the NPRM, which permits a 10,000 BTU/ft.^{2} hour flux level, a revision has been made to include the property line of the facility, if a structure is not the limiting feature. Consensus standards in existence for a number of years have imposed a similar restriction. Also, former category (5) of the NPRM has been deleted by incorporating "other structures made of cellulose, metal, or masonry materials" within category (6) of the final rule, in concurrence with two commenters. Where structures do not have the use features described under categories (3) and (4) and would not cause additional hazards if exposed to high levels of thermal radiation, there is no justification for imposing flux levels below 10,000 BTU/ft.^{2} hour.

The Final Evaluation shows that § 193.2057 would have a major cost impact on construction of a new LNG facility as compared to the baseline regulatory standard, NFPA 59A (1975 edition), because of additional land area that would have to be acquired. However, there are various options that an operator may choose to lessen the cost impact of this regulation, such as:

(1) Selection of a site which minimizes the need for construction of additional pipelines so that the combined cost of land and pipelines is not high.

(2) Choosing a site where, because of the nature of the surrounding area, the thermal flux permitted under this regulation would not require the acquisition of additional land.

(3) Locating a facility where local meteorological conditions would result in lower exclusion distances.

(4) Utilization of alternative plant designs to reduce the exclusion distances. For example, the use of either a Class 1 impounding system (§ 193.2153), cavern storage, or a larger number of small tanks would minimize the necessary exclusion distance.

The need to provide an exclusion distance to protect the public from the thermal radiation of a large fire on the LNG facility is of utmost importance in assuring the proper selection of such a facility.

Providing an adequate thermal radiation exclusion distance, which was one of the principal deficiencies in the NFPA 59A (1979 edition), will protect people who live or work near the facility by providing sufficient separation from the heat of burning LNG at the site. The current NFPA 59A (1975 edition) significantly strengthens the earlier NFPA 59A edition and approaches the exclusion distances established by this regulation. A discussion of the current NFPA 59A standard for thermal radiation exclusion distance is also discussed in the Final Evaluation.

Flammable vapor-gas dispersion protection. Most commenters agreed with the original language of § 193.2059(a). However, revisions have been made in § 193.2059(a) to make the language consistent, where appropriate, with § 193.2057. In response to comments, the term "frequently occupied" has been defined as "occupied by 20 or more persons during normal use." This should alleviate the concerns of one commenter who suggested using the term "regular organized outdoor assembly." In the same way, the term "exceptional value" is now based on "historic uniqueness" that is specifically described. The basis for these expressions is more fully explained under § 193.2057. A change to base the criteria for an exclusion zone on the percent of area covered by a plume was proposed by one commenter who claimed that isoplethis are very narrow. This proposal has not been adopted, since much remains to be learned about dispersion and gravity spread particularly when wind velocities are low and could result in large upwind and lateral dispersion.

Agreement with § 193.2059(b) was expressed by most commenters also. One commenter recommended a change to require that dispersion distance be determined by horizontal measurement rather than following ground contour. No explanation in support of this proposal was given. While vapor dispersion characteristics are still uncertain, some work currently in progress for the Department of Energy indicates that changes in elevation would tend to diffuse the vapor. Considering the range of accuracy expected with current dispersion models, the difference in distance should not be significant. Since using horizontal measurement, when preferred, would always meet distance requirements of following the ground contours, the MTB has not adopted this proposal.

Response to § 193.2059(c) was very extensive. The principal issue was the commenter's argument that provisions should be made to permit the use of new dispersion models when additional technical information is developed. Fifteen commenters suggested various methods by which this might be accomplished. Although MTB believes that present models may be conservative, diverse assumptions and results coupled with the lack of verification testing at appropriate scale cause much uncertainty. Accordingly, the MTB has included a provision for the use of models which meet specific criteria, including approval by the Director.

Commenters were critical of most current models. AGA IS-3-1 models were said to be based on questionable data and inappropriate because of being based on a sudden spill. One commenter strongly favored the models SLICE and SIGMET, but these models include certain assumptions and represent departures in principal and results. Although the MTB believes that these models may ultimately prove to be quite valid, verification is needed to justify the resulting reduction in conservatism. The model proposed in the NPRM was also widely criticized. Its ability to provide for only continuous spills, rather than sudden spills and spills of finite duration was viewed as a particular limitation. However, one commenter contended that it could be used if the method is modified to allow for finite spills. Commenters who criticized the NPRM model most extensively also recommend that the rule continue to reference that model for optional use. The MTB believes that modifications will allow for finite spills, but even if distance is based on a continuous spill, results will not be significantly different. Accordingly, the NPRM model is referenced in the final rule for optional application.

The TPSSC found this regulation unreasonable because part (c) requires use of a single questionable formula, without allowance for mitigating measures. The MTB believes that allowing the use of a model submitted by the operator for approval by the Director should satisfy the concerns expressed by the TPSSC.

A requirement to determine the dispersion distance for each impoundment met with objections from two commenters who argued that the impounding system needing the longer distance would control. Other commenters advocated retention of the feature. Since it is necessary to determine the dispersion distance in order to know which impounding system controls, the requirement has been retained.

A recommendation by 2 commenters to change the gas concentration from 2.5 percent to a range between 2.5 percent and 5 percent according to atmospheric stability has not been adopted because there are insufficient data to justify the change. Also, the IS-3-1 report suggested that 2 percent may be a more appropriate level.

The weather conditions under paragraph (c)(2) have been changed from a 95 percent level of nonexceedance to a 90 percent level, in accordance with a number of recommendations, since weather data shows the wind to be clam at least 5 percent of the time in most locations. In addition, optional weather parameters have been provided for use with some models in order to provide for locations where data are unavailable or to permit an operation to proceed with calcuations without extensive data compilation.

Section 193.2059(d) has undergone major revision. Numerous comments were made indicating a need for clarification of intent and often providing constructive suggestions which have been incorporated in the modification. Other changes were made because of changes in § 193.2061 on allowable seismic design. The TPSSC found the proposed regulation to be unreasonable because the Committee believed the prescribed vaporization rate was intended to exceed the combined discharge of LNG and flash vapor from the failed piping. This misunderstanding arose because of the term "LNG" before the word discharge in the second line of paragraph (d)(1)(i) of the NPRM. The adopted paragraph (d)(1)(i) restates the vaporization rate to show more clearly that it is the sum of vapor formed by flashing and from boiling due to heat transfer from contact surfaces. Also, the spill duration for top transfer and for side or bottom penetrations is spelled out. Provisions for an alternate model for determining surface contact conditions that meets prescribed criteria is included, consistent with the provision for other models.

Section 193.109(d)(2) of the NPRM proposed that vapor dispersion resulting from a prescribed tank failure be based on local seismic conditions and other surrounding conditions. In view of changes made in allowable seismic design, consideration of high seismic activity become less of a concern. Also, other provisions in the new standards, such as design of diking in the vicinity of airports, address hazards from the other surrounding conditions. Therefore, this paragraph has been deleted in its entirety. Objections by the TPSSC to the 0.4g seismic acceleration criteria and the credibility of the spill condition are thereby eliminated. In paragraph (d)(2), the safety factor of (2) on impoundment insulation has been eliminated in the final rules. Rather, performance reliability is predicated on testing and proper design installation and maintenance of the insulation.

The concept of planned ignition as set forth in § 193.2059(e) was found to be unacceptable by the TPSSC because of dangers to plant personnel. A large number of commenters also expressed opposition to planned ignition. It was argued that plant insurance would be difficult to acquire and that a minor spill could become a distinct hazard. One commenter expressed the view that the concept is controversial and repugnant at first thought, but adds that in the event of offsite dispersion, it may safeguard abutters with limited additional risk on site since offsite ignition would be likely anyway. The MTB has revised this requirement based on the significant number of commenters who are opposed to an ignition option. The revision permits the operator to prepare a plan for controlling the spread of LNG beyond the facility site. Methods, including igniting the LNG vapors, could be included in the plan. The operator can exercise the option on how the LNG will be controlled from spreading if a vapor dispersion exclusion zone is not practical to provide.

The Final Evaluation shows that § 193.2059 would have a major cost impact on the construction of an LNG facility as compared to the baseline regulatory standard, amounting to about 60 percent of the costs of the eight costly sections. Since the Draft Evaluation shows that the bulk of the cost would be due to land acquisition, most of the factors discussed under § 193.2057 on how land costs might be mitigated are equally applicable to § 193.2059. Even assuming a low probability of an accident that would cause flammable vapors to disperse beyond the plant site, MTB believes that the added costs are justified by the potentially disastrous effects that would result from the ignition of an LNG vapor cloud in a populated area.

The current NFPA 59A (1979 edition) strengthens the earlier NFPA 59A edition. A discussion of the current NFPA 59A standard for vapor cloud dispersion distance is also discussed in the Final Evaluation.

Seismic investigation and design. Section 193.2061 establishes site investigation requirements for ground motion caused by earthquakes to protect against the catastrophic failure of certain LNG facilities (see § 193.2051). In regions having a higher expectancy of earthquakes, these facilities would have to be designed to withstand, without loss of structural or functional integrity, the most critical earthquake motion which is ascertained probabilistically if such data are sufficient, or deterministically when available earthquake data are insufficient to provide probabilistic estimates. In regions having a lower expectancy of earthquakes, these facilities would be designed to withstand, without loss of functional or structural integrity, the forces in the Uniform Building Code, Vol. I, 1976 edition.

The geotechnical investigation for facilities in regions having a higher expectancy of earthquakes must include factors which would affect the seismic design of the facility. Factors such as faults, quaternary activity of those faults, tectonic structures, static and dynamic properties of soils, earthquakes, hydrologic regime, and potential for liquefaction must be included in the geotechnical investigation. Under paragraph (f), LNG storage tanks would be prohibited in locations having a potential for very high fault displacement, earthquake potential, or liquefaction.

Most of the commenters objected to parts of this proposed rule, most of the objections focusing on the proposed requirements mandating a probabilistic determination of the expectancy of an earthquake and the prohibiting of an LNG facility in certain locations. Most of the comments were general in nature without going into detail with regard to specific requirements. A few commenters did comment substantively with regard to the technical feasibility of each specific requirement. Some of these commenters relied on opinions by recognized experts in the design and construction of structures in seismic areas to prepare those comments.

On April 24 and 25, 1979, MTB held a conference in Washington, D.C., with representatives of Western LNG Associates, Inc., Bixby Ranch, American Gas Association, Hollister Ranch, and various representatives of operators having LNG facilities to discuss the seismic requirements proposed in § 193.111. The proposed requirements in §§ 193.107, 193.109, and 193.117, and Subpart E were also discussed, but not to as great an extent as the proposed seismic requirements. This meeting served to meaningfully discuss the proposed seismic requirements with people vitally interested in the seismic proposals, including eminent recognized experts in seismic investigations and design. This conference proved helpful in providing MTB the opportunity to gather information and discuss the proposed seismic requirements.

A few commenters to this proposal advocated that the seismic design requirements of the NRC be adopted. On the other hand, a few commenters advocated that the Uniform Building Code (UBC) design method is adequate, and therefore, should be used in the design of LNG facilities. While the probability of an earthquake occurring at a site does not depend on whether the site is for an LNG or nuclear facility, the nature of the hazard differs according to the type of facility. For instance, the release of LNG in an accident would not have the long term contaminating effects of escaping radioactivity, nor is the area affected by an LNG spill as widespread as the area affected by the wind-blown radioactivity of a nuclear release. Therefore, these differences should be reflected in different design standards.

Further, the requirements for nuclear plants use two levels of designs for earthquakes, one level at which the nuclear facility would continue to operate while another level at which the nuclear facility would be safely shut down and maintained in a shutdown mode. The MTB does not believe that two levels of design are appropriate for LNG facilities because hazards often cannot be reduced by shutdown, and has established a requirement that certain facilities must be designed and built to the critical ground motion without loss of functional or structural integrity.

MTB does not believe that LNG facilities should be designed to the standards in UBC in regions having a higher expectancy of earthquakes. The UBC does not take into consideration the function of the structures, such as the hazardous nature of an LNG facility nor does it consider the large area that would be affected by a catastrophic spill of LNG. A large number of commenters recognized the inadequacies of designing an LNG facility to the standards in UBC.

Because of the revisions to this section, it has been reorganized into a different format for clarity. The new format more clearly defines the requirements, in sequence, that must be conducted in the seismic investigation and design.

As suggested by a commenter, § 193.2061(a) which applies to sites in Zone 0 or 1 of the Seismic Risk Map of the U.S., UBC, requires a study of faults, hydrologic regime, and soil conditions to learn if there is evidence indicating a potential for surface faulting or soil liquefaction at the proposed site.

Section 193.2061(b)(1) sets forth the seismic loads to which facilities at the higher risk sites must be designed and built to withstand, without loss of structural or functional integrity. LNG facilities in Puerto Rico, Zone 2, 3, or 4 or at a site in Zones 0 and 1 determined to have a potential for surface faulting or soil liquefaction fall under this requirement.

Section 193.2061(b)(2) establishes the UBC as seismic design requirements for LNG facilities not subject to paragraph (b)(1). This part of the regulation has been revised in accordance with comments that the UBC does not designate horizontal or vertical seismic acceleration as proposed in the NPRM, but instead the UBC sets forth lateral forces.

A number of commenters suggested that the extent of the factors involved in a geotechnical investigation to determine seismic design loads should be set out in the regulation in order to assure an adequate and consistent seismic investigation. A listing of factors was originally suggested in the draft proposals in the ANPRM of this regulatory proceeding, but was omitted in the NPRM to avoid duplication of the proposed general requirement to conduct a geotechnical investigation. However, because commenters showed a need to specify the extent of the seismic investigation, MTB has included a few details of what an investigation should include in the final rule. These details are based on commenters' proposed criteria for conducting the geotechnical investigation. These criteria have been summarized and included in § 193.2061(c).

In keeping with practically all of the comments on this section that there are not sufficient earthquake data in most parts of the country to make a determination of the critical ground motion solely on a probabilistic basis, MTB has provided an option in paragraph (d) that the most critical ground motion may also be ascertained deterministically when available earthquake data are insufficient to provide probabilistic estimates. During the course of this rulemaking, MTB has concluded that there are regions in the country that, in the future, probably will have sufficient earthquake data to determine critical ground motion on a probabilistic basis with a yearly probability of exceedence of 10^{-4} or less as proposed in the NPRM. The MTB believes that a probabilistic determination of critical ground motion is the preferable approach because if derived from adequate data, it will establish a common basis of seismic design for all LNG facilities.

The criteria in § 193.2061(e) that must be investigated in determining critical ground motion are in accordance with the views of commenters that proposed such a requirement. Including this requirement, according to these commenters, is necessary to assure a common basis for determining critical ground motion. The MTB agrees and has adopted this suggestion. Some of the criteria have been revised to assure that there is definitiveness in the terms, in order to assure a consistent determination of critical ground motion. A revision has been made to the commenters' proposal with regard to critical ground motion by establishing that the vertical design response spectra are equal to the horizontal design response spectra within 10 miles of the earthquake source. This requirement is consistent with earthquake data that indicate that the vertical and horizontal response spectra are essentially similar at distances of 10 miles or less from the earthquake source.

Section 193.2061(f) prohibits an LNG storage tank from being located in certain areas of high seismic activity. This regulation differs from that proposed in the NPRM in order to establish both a magnitude as well as the frequency for seismic activity. Most commenters argued that LNG facilities should not be prohibited at any location, arguing that designers could design an LNG storage tank to accommodate almost any seismic force. During the conference on April 24 and 25, 1979, in which the proposed seismic requirements were discussed, some witnesses argued that the storage tank could effectively withstand horizontal or vertical displacement of a fault directly under the LNG tank. However, one witness disagreed with that argument, saying that a design to withstand the horizontal or vertical displacement of a fault directly under the LNG tank has not undergone the test of a real earthquake displacement. The substantive written comments on these proposed prohibited areas argue that areas of severe seismic activity should not be prohibited, but an approval by the Director should be required in these areas. These comments categorize different ranges of fault displacement and the type of foundation construction required in these areas.

The MTB is not convinced that LNG storage tanks should not be prohibited in areas of very high seismic activity. The MTB believes that the consequences of a very severe earthquake are so significant that it is not in the public interest to permit construction of an LNG storage tank in these areas. The MTB believes that because LNG storage tanks have not experienced very severe earthquakes, there has not been substantiation of arguments by commenters that such earthquake forces can be handled by appropriate design. Therefore, MTB has retained the prohibitions of LNG storage tanks in areas having high probability of severe seismic activity. So, with appropriate revisions, MTB has prohibited as LNG facility sites those locations that some commenters proposed should require MTB approval. As for any MTB safety rule, the Director would evaluate a petition for waiver of these prohibitions if an operator demonstrates why they should not be followed and how the public would be protected by deviating from them. With regard to the requirement in the NPRM prohibiting LNG storage tanks in areas of severe seismic activity, the 1-mile distance from a fault has been retained because faults cannot be defined more precisely when considering uncertainties in the nature of a fault. In addition, the probability of a splay from a fault would make the area of hazard difficult to define; however, the proposed prohibition has been modified to consider recency of movement and amount of movement in any way similar to that proposed by a commenter. The recency of movement is based on the determination of movement within Quaternary time rather than over the last 35,000 years, as proposed by the commenter, because MTB believes that the last 35,000 years is not a sufficiently long period to assure prediction of subsequent seismic activity. The prohibiting of an LNG storage tank where the estimated design horizontal acceleration at the foundation exceeds 0.8g is adopted because such a load is cause for questioning the selection of a site that would be subjected to such severe seismic activity. In accordance with various commenters, the prohibition regarding liquefaction recognizes that the potential for such a phenomenon can be mitigated.

Section 193.2061(g) has not been changed from the NPRM because there were no substantive comments on this section.

The TPSSC stated that the concept of the seismic investigations as proposed in the NPRM is appropriate, but, as proposed, was neither reasonable nor practicable. They recommended that MTB review the testimony of Mr. James Devine, U.S. Geological Survey, at the meeting. The MTB has used Mr. Devine's testimony, as well as utilizing Mr. Devine, in developing this final rule.

The Final Evaluation shows that § 193.2061 would have a major cost impact on construction of an LNG facility as compared to the baseline regulatory standard because of the more detailed seismic investigation and more stringent seismic design requirements, such as the added cost of structural steel, concrete, and earthwork. While the Final Evaluation concludes that the occurrence of an earthquake is unlikely, MTB believes that the consequences of a major earthquake are so devastating, as illustrated by damage to structures from previous earthquakes, that LNG facilities must be designed to prevent the failure of various components from such an occurrence. The requirement for seismic investigation for design in the current NFPA 59A (1979 edition) is not very different from the requirement established by this regulation. A discussion of the current NFPA 59A standard for seismic design is also discussed in the Final Evaluation.

Flooding. The principal concern of several who commented on § 193.2063 related to the risk of flooding against which protection would be required. Three suggested that the level of risk be changed to a more stringent level, such as the 500-year flood plane used in the guidelines of the Water Resources Council. While MTB believes that risk levels should be uniform, data relating to different environmental phenomena have not been uniformly determined. In the case of flooding, many different events are involved and combined to describe the worst event expected based on a 100-year interval. Based on present data, however, the MTB is not convinced that a change to impose more stringent risk levels is necessary. Accordingly, the wording proposed in the NPRM has been retained in the final rules.

The TPSSC felt that a clarification was needed to show that every foundation need not be protected against flooding. Another clarification showing that the operator is not responsible for a power supply over which the operator has no control was recommended by the committee. As discussed above, the components and foundations to which § 193.2063 applies are listed in the scope (§ 193.2051) of Subpart B. Another provision in § 193.2051 shows that responsibility for protection of power supplies applies to either normal or auxiliary power facilities associated with facilities to which Subpart B applies. Only LNG facilities used for power supply are intended to be covered, not facilities beyond the operator's control.

The Final Evaluation identifies § 193.2063 as a major cost item due to the cost of additional concrete and earthwork needed to protect the facility against the occurrence of a flood. The Final Evaluation concludes that the occurrence of a flood is unlikely. However, if a flood does occur, MTB believes that its consequences would result in significant damages and perhaps a catastrophic failure if the foundation of an LNG storage tank or other significant component is undermined. The MTB believes that major benefits would accrue through prevention of such a catastrophic failure.

Soil characteristics. Most commenters and the TPSSC agreed with the proposed language of § 193.2065(a). One commenter recommended use of the Nuclear Regulatory Commission (NRC) regulatory guide 1.132 as a baseline to assure a thorough investigation. Another commenter felt that a requirement for a determination of the dynamic properties of the soil should be added. The MTB does not consider the NRC guide to be an appropriate baseline for LNG facilities in view of the wide range in size and complexity of LNG facilities as well as the difference in nature of the hazards between an LNG and a nuclear facility. Also, the proposed rule included requirements relating to a soil's dynamic properties. Therefore, § 193.2065(a) is unchanged.

Approval of § 193.2065(b) was indicated by most commenters also. One commenter, however, felt modifications were needed to allow for conditions other than natural soil properties on the basis that soil can be improved by technical means. Although the proposal did not intend to preclude the use of engineering techniques to improve natural soil conditions, the final rule clarifies this point by use of the terms "naturally occurring or designated" to describe the soil characteristics that must be provided at a site. The TPSSC recommended that the term "rollover" be deleted as a dynamic load because other rules require its control. Although MTB prescribes measures for the control of rollover, because such a possibility can occur due to human error, occurrence of the phenomenon is not totally precluded. Because rollover would result in vibration and other dynamic loading, the rule has been retained as proposed.

Wind forces. Most commenters and the TPSSC approved § 193.2067(a). However, based on recommendations by commenters and consistent with overall modifications to eliminate the term "critical component," paragraph (a) has been substantially rearranged and modified. In § 193.117(a), the term "critical component" has been eliminated by defining the components subject to the requirements according to the hazards which must be considered. Specific conditions that must be evaluated and accommodated by design are prescribed based on specific comments. Two commenters recommended that the rules include requirements to design for (1) the direct drag and lift forces of winds and (2) the pressure differential across dividing portions of a partial or total enclosure. These commenters plus two other commenters advocated the inclusion of impact forces and partial penetration from wind borne missiles. Another commenter proposed that pressure gradients due to tornadoes be addressed. This proposal falls into the more generally described condition described in proposal (2) above. The MTB agrees that these recommended design considerations should be specifically designated, and paragraph (a) has been modified accordingly.

With respect to § 193.2067(b), both the design wind speed and the method for determining wind speed were the primary issues. Several commenters proposed that the rules permit both probabilistic and deterministic methods for establishing wind speed in a manner similar to the alternate procedures proposed for seismic design. This proposal was not accepted because MTB does not know of previous practices of establishing wind speed deterministically. A change to increase the probability of occurrence to 10^{-3} or more was also advocated. The MTB believes that because damage and uncertainties associated with high winds, such as tornadoes, are comparable with seismic effects, the proposed probability should be retained. However, a requirement to determine wind speed based on the probability of nonexceedance has been prescribed in accordance with recommendations by nine commenters. The MTB agreed with this recommendation, since setting a fixed wind speed is analogous to setting earthquake intensity based solely on the probability of occurrence. Therefore, under the final rules, the most critical combination of velocity and duration must be established probabilistically when the data for such a determination are available. However, because these data are not uniformly available throughout the country, the rules set forth an alternate fixed velocity to be used when a probabilistic determination is not possible. Many commenters objected to the 250 miles per hour design windspeed specified in the NPRM. On the basis that a study by one expert indicated that 98 percent of tornadoes have velocities below 150 miles per hour, a commenter argued that 200 miles per hour is a more realistic and less costly wind speed to use. Another commenter recommended a 210 mile per hour speed if local data is unavailable because only 2.3 percent of tornadoes have velocities above 207 miles per hour and 62 percent have speeds of 112 miles per hour or less. Other commenters made similar arguments. One commenter said that less than 1 percent of tornadoes have winds exceeding 250 miles per hour, and another commenter stated that Nevada had never experienced winds as high as 250 miles per hour. The TPSSC found the proposed standard to be unacceptable, stating the 250 mile per hour speed should be reduced because it is excessive. The MTB recognizes that there is a lack of valid wind speed data for tornadoes. Even data on the occurrence of tornadoes is not wholly reliable since many tornadoes have not been reported, and velocities are frequently unmeasured. The MTB is aware that recent reports have contended that tornado wind speeds are less than previously thought to be. In accordance with this understanding and documented recommendations, the design wind speed has been revised from 250 to 200 miles per hour, which is to be used only if local wind data are inadequate, and a lower speed would be allowed if justified and approved by the Director.

A revision to reference ANSI A 58.1 rather than UBC for wind loading applicable to small shop fabricated tanks was recommended by six commenters. The UBC standard was said to be less current and not applicable to critical structures. Four other commenters also proposed that the reference to UBC be changed, but did not suggest an alternative. The MTB recognizes that UBC is not intended for highly critical structures and expects that future editions of UBC may indicate this limitation. Therefore, in accordance with recommendations by commenters, the related reference has been revised.

The Final Evaluation identifies § 193.2067 as a major cost item as compared to the baseline regulatory standard because of the design for high wind loads and the low probability of occurrence of such wind loads. The MTB believes that the provision for the high wind load design is necessary to mitigate the catastrophic failure of an LNG storage tank from such winds. Previous failures of structures due to excessive wind loads clearly illustrate the severe consequences of such a failure. The need to protect against the consequences of a failure of the tank is very important to properly protect the public who live or work near the facility. The design for wind loads in the current NFPA 59A (1979 edition) approaches the design established by this regulation. A discussion of the current NFPA 59A standard for wind load design is also discussed in the Final Evaluation.

Other severe weather and natural conditions. The majority of commenters supported § 193.2069 without modification. One commenter proposed to change the words "a hazard," appearing in § 193.2069(b), to "the occurrence of an uncontrollable emergency." Otherwise, a definition of hazard was said to be necessary. Also, the TPSSC reported that the word "hazard" does not express the intent. The MTB agrees that the word "hazard" was inappropriate. Changes in this respect have been made to other sections based on response and discussion of the NPRM. Accordingly, the wording has been revised to "an emergency."

Adjacent activities. A revision to § 193.2071(a) changes the words "persons and property" to "persons and offsite property" and deletes the qualifying phrase "located off the site." This makes the language consistent with other sections.

In § 193.2071(b), the word "safety" has been added to describe "control systems," based on one recommendation, since it is clearly not the intent of MTB to impose regulatory burdens of LNG facilities that are not safety-related.

Separation of components. Although § 193.123(b) in the NPRM was supported by many commenters, some, however, felt that the intended provisions regarding spill and collapse hazards were adequately covered by 59A as referenced in § 193.2073(b). The TPSSC held a similar view, calling for the wording to be clarified so as to express the intent described in the transcript of the hearings. Concern was expressed also that it could be interpreted to mean that exclusion distances required by Subpart B for thermal radiation and vapor dispersion must be provided within the plant. The MTB agrees that the requirement is not necessary and could cause confusion. Therefore, it has been deleted in § 193.2073.

Subpart C—Design

Materials. Several commenters to § 193.2103, General, pointed out that every component need not be qualified under Subpart B and thus the Subpart B environmental forces should not apply to every component under the terms of § 193.2103. In view of the change in the scope of Subpart B, the wording of § 193.2103 has been clarified to state that Subpart B design requirements are not to be applied to components unless applicable under that subpart. The words "within design limits" were added after "compatible" in § 193.2103(b) for purposes of clarity.

Section 193.2107(a), Extreme temperatures, has been rewritten to better express the intent. Based on the comments of the TPSSC and others, § 193.2107(c) has been revised to recognize that emergency response may be provided to delay failure to allow adequate time for other measures to be taken. It was pointed out that the proposed "two hours" criterion is adequate in some instances and inadequate in others.

The MTB finds that the subject of § 193.2109, Insulation, and terminology associated with it, are presently in a state of flux. Section 193.209 of the ANPRM used the term "which do not support combustion." Based on a large number of comments by operators and associations, this was changed to "self-extinguishing" as a more generally accepted term by these commenters. This was reiterated by their comments on the NPRM.

However, this brought forth comments from the Federal Trade Commission (FTC) and from several insulation manufacturers, who had not previously responded, calling attention to the order and decision of the FTC dated November 4, 1974, which prohibits the use of publication of such terms as "non-burning," "self-extinguishing," "non-combustible," or any term of like meaning to describe the burning characteristics of cellular plastic products. Presumably this prohibition does not necessarily extend to other forms of insulation.

One commenter pointed out that the Thermal Insulation Manufacturers Association is working towards the establishment of a standardized pipe insulation fire test which would indicate actual fire performance. It was recommended this test be used in specifying fire performance *when* it becomes available. The MTB is willing to consider this suggestion at that time.

It is MTB's position that insulation or coverings other than cellular plastic products can be used and can be rightfully termed "noncombustible." This term is therefore being used in this part until such time as other agencies or the industry develops new criteria.

It is significant that the draft of NFPA 59A-1979 uses this term in paragraph 4113.

There were many other varying comments in regard to insulation in § 193.2109. The requirement that the covering must have a melting point above 1500° F has been deleted, as MTB agrees this would preclude use of other materials other than steel which would be adequate in many cases. Most commenters argued that the 1500° F requirement was unnecessarily restrictive. The need to withstand the force of fire hose streams has also been deleted as this is only one possible source of impact loading, and it may be questionable whether it would be practical to withstand the force of streams developed by modern firefighting equipment.

The TPSSC agreed with the intent of § 193.2111 dealing with cold boxes, but felt the wording was ambiguous. This has been changed for clarification.

The revised definition of "hazardous fluids" should meet the many objections to the use of that term in § 193.2113 dealing with piping.

The MTB agrees with the commenters on § 193.2117, Combustible materials, that "is impractical" better expresses the intent rather than "not commercially available."

Records are required by § 193.2119 as well as elsewhere in this part are required by MTB to verify compliance with these regulations. It is not believed this is a burden, as this information is available during the design and construction of a facility, and should be retained.

Design of Components and Buildings

Section 193.304 of the NPRM is now § 193.2703 of the new Subpart H—Personnel Qualifications and Training.

Particularly based on the recommendation of the TPSSC, the several sections of this part pertaining to valves have been reorganized. Section 193.2123 pertains to the design of all types of valves used in an LNG facility. Section 193.2123(a) and (b) have been added; they are taken from paragraphs 6130 and 6131 of NFPA 59A, the interim standard now in effect in Part 192. The ban on use of cast, malleable, and ductile iron valves in paragraph 6132 is covered by § 193.2113 of this part. Section 193.617(d) of the NPRM has been revised and is now § 193.2123(e), as this does pertain to design.

Section 193.917 of the NPRM is now titled "automatic shutoff valves" and is now § 193.2125, as it lists specific design requirements for such valves.

Valves for specific requirements associated with equipment are covered in the appropriate subparts.

Section 193.2127 has been revised to correct the seemingly contradictory or conflicting requirements in (d) and (e) of the NPRM. A number of commenters offered similar requirements which have been adopted.

As suggested by the TPSSC, the word "pipe" has been changed to "piping" in § 193.2129 and elsewhere in these regulations where the word "piping" is more appropriate. Section 193.2129(a) of the NPRM has been deleted, as it was not the intent that all pipe supports comply with extreme temperature requirements.

Section 193.2131, Building design, has been rewritten to incorporate paragraph 220 of NFPA 59A, as being more meaningful, yet providing the original intent.

In § 193.2133, Buildings, ventilation, "15 percent" has been changed to "25 percent" in (a)(2) and (3), based on the consensus of comments and the recommendation of the TPSSC. This becomes consistent with other sections of this part.

The word "determine" was changed to "consider" in § 193.2135, as MTB agrees that calculations involved in a rigorous investigation are not required for many components.

The alternative inspection requirement in § 193.2137 in respect to frost heave has been modified to permit the operator to use a method and schedule to detect changes in elevation as included in the maintenance procedures required by this part.

The requirement for lightning rods and arrestors has been deleted in § 193.2143, as it is agreed that proper electrical grounding is adequate to protect personnel and components in an LNG facility.

The title of § 193.2145 has been changed to "Boilers and pressure vessels" as this section does pertain to both subjects.

Regarding § 193.2149, the majority of the commenters and the TPSSC objected to the mandatory requirement for an impounding system for transfer lines in excess of 4 inches in diameter and for cargo transfer systems. This was in response to the MTB request in the preamble of the NPRM for comments as to a diameter break point for transfer lines. It was pointed out that the many factors involved, such as diameter, pressure, length, or location precluded the establishment of such a break point. Accordingly, MTB now mandates an impoundment system for storage tanks, but uses performance language in § 193.2149(b), allowing an operator to use grading or drainage or, where necessary, an impounding system, depending on site related conditions, for the listed components.

Commenters and the TPSSC stated that in § 193.2151, the term "under the worst predictable spill conditions" was an undefinable term, and not practical or reasonable. Accordingly, this term has been deleted.

In spite of the justification presented in the preamble of the NPRM, commenters, including the TPSSC, objected to classification of impounding systems in § 193.2153. The MTB believes this is required for use in other sections of this part. Section 193.2153(a), Class 1, has been revised to permit a 24-inch space between the system and the component served. This may be done for construction or maintenance reasons, yet meets the objectives of a Class 1 system.

Section 193.2155(c) has been revised to indicate that this requirement applies only to large airports serving large aircraft as defined in 14 CFR Part 1.1.

In § 193.2157, as elsewhere, "self-extinguishing" has been replaced by "noncombustible." Section 193.2117(c) is now applicable only when the insulation is used to maintain the functional integrity of an impounding system.

Section 193.2159(d) has been revised to eliminate mandated changes, as it was pointed out other methods may be used to minimize the wetted floor area.

In spite of repeated comments and views of the TPSSC, MTB stands by its position expressed in the NPRM that dike penetrations be prohibited. It is felt it is in the interest of safety to prohibit them, and that furthermore they are already prohibited by a number of existing local ordinances.

The MTB agrees that "detain" is a more appropriate word that "entrain" in § 193.2163, and has made this change.

As suggested, "membranous covering" has been replaced by "flammable nonmetallic membrane" in § 193.2167(b). This is now consistent with § 193.2187(b).

Section 193.2169 is essentially the same as proposed in the NPRM. There were few comments to this section.

The Final Evaluation shows that § 193.2169 would have a major cost impact because of the instrumentation that would have to be provided to detect leaks. The MTB believes that the added costs are justified by the early warning that would be provided should a leak occur. Even with a minor leak, the extreme cold of LNG could produce excessive localized thermal stresses in surfaces contacted. Resulting cracks could damage the structural integrity of a component making it susceptible to a possible catastrophic failure. In addition, with current design of high dikes located closely adjacent to a component, a small leak of either LNG or cold gas could result in a combustible mixture forming between a component and its diking. The current NFPA 59A (1979 edition) has revised this standard so that it is very similar to § 193.2169. A discussion of the current NFPA 59A standard for gas leak detection is also discussed in the Final Evaluation.

In § 193.2171, a sump basin is required only for collection of water. A small spill of LNG would probably evaporate before reaching the sump basin, and if it reached the sump basin, it would evaporate from that location. Commenters and the TPSSC felt other means could be used to contain small spills of LNG, if necessary. There did not appear to be any objections to a sump basin for water; and therefore, this requirement has been retained.

A more acceptable parameter has been established to define the average predictable collection rate of water from a storm in § 193.2173. The majority of commenters stated that the water collection rate as required in the NPRM was unreasonable and would require excessively large pumps. The proposed mandatory requirement for automatic operation of sump pumps has also been deleted. The TPSSC felt the requirement for sump pumps was unreasonable as it restricted alternate methods of water removal, although it did not suggest what such methods could be.

Section 193.435 in the NPRM has been deleted and included in § 193.2107.

The TPSSC stated that § 193.2179(a) was impossible to understand and technically inappropriate. In response, MTB has deleted paragraph (a) in the NPRM, but has retained paragraph (b) dealing with capacities for displacement.

Section 193.2181 covering impoundment capacity of impoundment systems is unchanged except for the addition of (b), which clarifies the status of covered impoundment systems. The MTB still believes the discussion of this section in the preamble of the NPRM is still valid and need not be repeated here.

Section 193.2183, Impoundment capacity; equipment and transfer systems, and § 193.2185, Impounding capacity; parking areas, portable vessels, have been modified to be consistent with the revision of § 193.2149.

The section in the NPRM, § 193.445, has been deleted, as MTB agrees the requirements are actually covered in other sections of this subpart.

Likewise, § 193.447 of the NPRM has been deleted, since it serves no purpose with the deletion of § 193.429 of the ANPRM covering spill removal, regarding which MTB recognized that the many problems involved overode the potential benefits. As impoundment systems are designed for containment, sump basins within them serve no purpose.

LNG Storage Tanks

Section 193.2189(d) dealing with loading forces was revised to be consistent with other standards, such as paragraph 4-12.7 of NFPA 59A, stating the minimum density of LNG to be assumed. Some commenters felt this section was unnecessary, as the loading forces listed were covered by referenced standards. The MTB feels it is well to include them as given in this subpart.

Section 193.2191, Stratification, has been changed by replacing "by" with "such as." This would permit use of other satisfactory mitigating measures.

Section 193.2193, Movement and stress, has been retained. There were no objections, although, like § 193.2189, commenters pointed out the requirements were covered by referenced standards.

Section 193.2195, Penetrations, has been revised substantially. Practically all commenters objected to the proposed prohibition of penetrations below the liquid level. They pointed out many pros and cons for top and bottom connections. Although top connections were viewed as perhaps inherently safer, it was argued they pose other problems: submerged pumps in the tank, which would require means of withdrawal, with associated hazards to personnel; the tank structure and roof would require strengthening; the roof could be exposed to spills; a greater number of pumps would be required due to pump design limitations; and high voltage power would have to be provided for pump motors. Most commenters, including the TPSSC, stated that side penetrations could be designed to be at least as strong as the tank shell or stronger. Some commenters and the TPSSC felt such connections should be permitted if suitable safety precautions were provided.

Accordingly, MTB now requires tanks to be designed with penetrations in accordance with API 620, including Appendix Q, providing an analysis is made of all contributing forces, and that an internal shutoff valve be provided on all penetrations below the liquid level. Paragraph (d) has been added to establish separate design requirements for penetrations of LNG storage tanks having a capacity of 70,000 gallons or less because of the special design and quality control of such tanks.

Because of the requirement that an internal shutoff valve be provided on all penetrations below the liquid level, the Final Evaluation shows that § 193.2057 would have a major cost impact as compared to the baseline regulatory standard, NFPA 59A (1975 edition). The MTB believes that because penetrations below the liquid level in the storage tank expose the facility to a high risk of failure, an internal shutoff valve is a necessary requirement to protect against such an event. The cost of an internal shutoff valve when compared to the consequences of a spill through the bottom penetration of an LNG storage tank is clearly seen to be justified.

Section 193.2197, Internal design pressure, drew many comments, largely due to misunderstanding of the intent and the wording of the section. The MTB recognizes that consideration must be given to vapor handling equipment, relief devices or other mitigating measures to establish the internal design pressure. The section has been modified to clearly recognize this. Also, the operator must now "establish" rather than "determine" the design pressure. Paragraph (b)(2) no longer states any cause for rollover.

Section 193.2199, External design pressure, presented the same problems as § 193.2197 and has likewise been revised to clarify the intent.

Most commenters on § 193.2201, Internal temperature, could not understand why such a very accurate determination of internal temperature was necessary. The MTB concurs with the TPSSC that the LNG tank and tank components be designed for the lowest temperature which can be attained.

In § 193.2203, Foundations, the second sentence of (a) has been deleted, as this is only one design consideration out of many. Paragraph (c) has also been deleted, as it is redundant with § 193.2063.

The redundant instrumentation requirements for all instrumentation have been revised in § 193.2209. Paragraph (a)(5) has been revised to "abnormal temperature in tank structure" rather than "excessive thermal stress in tank structure" as it is questionable whether thermocouples could provide stress values. Here also the different instrumentation required for tanks with a capacity of 70,000 gallons or less is now recognized in (b).

As stated in the preamble to the NPRM, MTB agrees with most of the commenters that § 193.2213 was inadequate in respect to design of concrete tanks and that section 42 of NFPA-59A should be used. After review of this section, MTB concurred. This revision drew little comment. However, at the TPSSC meeting, the question was raised and considerable discussion ensued in respect to several references in NFPA-59A concerning their validity and which could have possible legal effects. To date, MTB has been unable to substantiate these claims. It is also significant that in NFPA-59A-1979, these references have been retained.

Section 193.535(d), involving support systems, now permits an air space between the tank bottom or its foundation, if designed to withstand forces caused by the ignition of a combustible vapor cloud in this space. The MTB believes such a design would provide adequate safety. One commenter presented a detailed independent study showing such a design is feasible.

Paragraph (b) of § 193.2219, Internal piping, has been deleted as MTB agrees that the availability of internal excess flow valves for LNG is questionable at this time, and they could provide a false sense of security, as in most cases only a complete rupture of a line would make them operable.

Design of Transfer Systems

§ 193.2223(c), the term "cryogenic temperatures," has been changed to "in transfer systems for LNG or flammable refrigerants" for clarity. Paragraph (d) has also been revised, as MTB recognizes that a cooling medium must be used to precool piping prior to normal operation of transfering cold fluids.

Section 193.2225 has been deleted because it is redundant with similar requirements in other sections.

As previously stated, all sections dealing with valves have been reorganized so that they more specifically apply to the subpart in which they appear. This is the case in § 193.2233, which deals with shutoff valves in transfer systems.

Subpart D—Construction

Section 193.2305, Procedures, now has more appropriate wording in (a) because of the deletion of the term "critical process."

Although no commenters objected to the intent, the TPSSC stated it was unreasonable that this requirement be applicable to all components, and should apply only to those components which affect safety. The MTB feels that an operator would have written specifications, procedures, and drawings, as appropriate, for all components in any case, and cannot foresee any undue hardship because of this requirement.

Section 193.1009 in the NPRM, dealing with qualification of personnel, is now § 193.2705 in Subpart H—Personnel Qualifications and Training.

Section 193.2307(c), Inspection, has been revised for clarity and to use generally accepted terminology.

Section 193.2313(f), Welding, has been deleted because a requirement for capture and disposal of contaminants would have been redundant with other sections of this part. This was suggested by TPSSC and commenters.

Because of several comments on § 193.2315(a)(2), joining of copper piping by brazing is permitted only in nonflammable service. It was pointed out that such joints will fail rapidly if exposed to fire. In (b), 0.63 was changed to 0.063 to correct a typographical error. Section 193.2315(d) has been revised to require that compression-type couplings must meet the requirements of ANSI B31.3. The MTB is satisfied that these requirements provide for safe use of such couplings under the conditions established in that standard. Paragraphs (e) and (f), taken from paragraphs 6-3.1.1 and 6-3.2.4 of NFPA 59A, have been added to afford a greater degree of safety.

In § 193.2319, Strength tests, MTB recognizes that pneumatic testing is required for certain LNG facility piping and that such testing has been carried out as accepted practice at lower levels than that required for hydrostatic testing because of possible hazards to property and personnel. Paragraph (b) has been revised accordingly and should be consistent with the suggestions of the commenters and the TPSSC. Paragraphs (a)(3) and (4) have been deleted, as these forces are provided for in design, and strength tests for weight of ice or snow and environmental forces such as seismic or wind cannot be practically accomplished.

Section 193.2321, Nondestructive tests, is virtually unchanged, despite the comments to the ANPRM and NPRM. The MTB believes the required testing provides for safer installations, and has expressed its views in detail in the preamble of the NPRM. The TPSSC considered this section to be feasible, reasonable, and practical as written. Paragraph (d) was modified and (e) was added to recognize and differentiate between the applicable codes for low and high pressure tanks.

The Final Evaluation shows that § 193.2321 would have a major cost impact as compared to the baseline regulatory standard, NFPA 59A (1975 edition). The MTB believes that the additional testing, which would be done by personnel already at the site, can be justified because of the importance of assuring that piping welds be sound and not affect the integrity of the pipe. The MTB believes that it is vitally important that all piping welds be tested, rather than 30 percent as set forth in the baseline regulatory standard. The current NFPA 59A (1979 edition) has revised this standard so that it is similar to § 193.2321. A discussion of the current NFPA 59A standard for nondestructive tests is also discussed in the Final Evaluation.

The MTB has revised § 193.2327, Storage tank tests, so as not to require that an LNG tank be filled with water to its maximum liquid level. As the maximum density of LNG is less than half that of water, a tank and its foundation would have to be designed to carry the weight of water involved for the duration of the test and not for the weights involved for the rest of the life of the tank. Many of the comments pointed out other factors such as overloading and possible long-range failure of the insulation under the tank, and possible need for piling of foundation to carry the weight of water. The TPSSC states such a test would not be reasonable or practical, as it would not achieve objectives expressed by staff. Most commenters objected to the preamble statement in the NPRM that overstressing of materials and foundation should mitigate the onerous aspects of this test, stating that few operators would risk such overstressing. It was also pointed out that the 100 percent radiographic testing of all welds, as well as other tests normally carried out, would ensure the integrity of the upper portion of the tank, which is subject to low stress levels in any case.

The MTB has therefore revised § 193.2327, requiring tests be in accordance with API 620, Appendix Q, for tanks with internal design pressures of not more than 15 psig; and in accordance with Section VIII of the ASME Boiler and Pressure Vessel Code. It must be pointed out that, in accordance with API 620, if ground bearing or the foundation provides sufficient support, the storage tank would have to be filled with water to the limits of that support.

Subpart E—Equipment

Vaporization Equipment. Consistent with the revisions of other sections of this part, MAOP has been replaced by MAWP in § 193.2405.

In § 193.2407, Operational control, some of the monitoring devices required in (a) were not feasible or needed, such as inlet and outlet temperature of heating medium fluids. The paragraph has been revised to require only pertinent information. Gas leaving the vaporizer is now termed vaporized gas, to distinguish it from natural gas which may be used as the heating medium.

Section 193.2411, Relief devices, has been revised to reference § 193.2429 in its entirety as it is now written.

Liquefaction Equipment

The MTB agrees that § 193.807, Contaminants, in the NPRM, is an operating problem not related to safety, and consequently this section has been deleted.

Some commenters stated that § 193.2421, Cold boxes, did not recognize that some cold boxes operate with a gaseous atmosphere rather than air or inert gas. The MTB has revised this section to provide requirements for the different atmospheres which may be maintained in a cold box.

Control Systems

Based on the opinions of commenters and the TPSSC, MTP agrees that all signal lines installed for control systems need not be routed separately, as required by § 193.2427(d). Such separate routing is now required only on those lines that can affect the operation of a component that does not fail safe.

Section 193.2429, Relief devices, now consolidates all requirements in respect to relief devices, pressure and vacuum, and is referenced in sections where such requirements are applicable. A number of changes have been made, such as the requirement that introduction of air under excess vacuum conditions must not create a flammable mixture. The MTB recognizes that such introduction of air through a vacuum relief would probably create such a mixture at the interface of the LNG vapor and air, but that (1) there would be no source of ignition and (2) such admission would prevent a possible catastrophic failure.

The MTB believes this, with other changes made, retains the basic intent of the section, yet resolves the problems commenters and the TPSSC had with the original wording.

Section 193.917 of the NPRM, Shutoff valves, more properly dealt with, and is now § 193.2125, automatic shutoff valves. An automatic shutoff valve would include the valve controller. This would meet the TPSSC objection that the controller (and the valve) be fail-safe, rather than the valve itself.

Section 193.2439 deals only with emergency shutdown control systems, rather than all systems, many dealing with operations having no connection with safety. The TPSSC and other commenters stated that § 193.605 of the

NPRM was unnecessary, and urged that the appropriate requirements should be incorporated in § 193.2439. This has been done. It was pointed out that paragraph (a)(4) of the NPRM, requiring shutdown based on the failure of a component, would be a requirement that is too general and undefined. The new (a)(5) more properly states the conditions. Also, as suggested by the TPSSC, 25 percent in (a)(4) has been changed to 40 percent, to be consistent with the requirement in § 193.2439(a)(4).

Based on the recommendation of the TPSSC and others, § 193.2445 has been revised to require two sources of power for emergency lighting, not all lighting. This is defined in the National Electrical Code as "illumination essential for safety to life and property."

Subpart H—Personnel Qualifications and Training

This new subpart is a result of the coordination between MTB and USCG in developing a common numbering system for the two agencies' regulations which would make both sets of regulations easier for the public to understand.

All sections pertaining to personnel qualifications and training will be consolidated in this subpart.

At present, only two sections are included, § 193.2703, dealing with design, and § 193.2705, dealing with construction. Others will be added as the balance of Part 193 is adopted.

The wording suggested by the TPSSC is being used in § 193.2703 as more properly expressing the intent.

Section 193.1009(b) of the NPRM has been deleted, as MTB agrees with commenters and the TPSSC that use of qualification tests for all activities is unwarranted.

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Of particular assistance in the preparation of these rules were the comments and report provided by the TPSSC as a result of a meeting held on June 12–15, 1979, in Boston, Massachusetts. Also, a conference held on April 24 and 25, 1979, in Washington, D.C., with various industry and public representatives to discuss the proposed seismic, vapor dispersion, thermal radiation, and wind force requirements was of considerable assistance to MTB. Finally, MTB thanks all of the commenters for the information and comments that were used in shaping these final rules.

Issued in Washigton, D.C., on January 30, 1980.

L. D. Santman,

Director, Materials Transportation Bureau.

Title 49, Code of Federal Regulations is amended by adding a new Part 193 to read as follows:

PART 193—LIQUEFIED NATURAL GAS FACILITIES: FEDERAL SAFETY STANDARDS

Subpart A—General

Authority: 49 U.S.C. 1671 et seq.; 49 CFR 1.53, Appendix A of Part 1, and Appendix A of Part 106.

Subpart A—General

§ 193.2001 Scope of part.

(a) This part prescribes safety standards for LNG facilities used in the transportation of gas by pipeline that is subject to the Natural Gas Pipeline Safety Act of 1968 and Part 192 of this chapter.

(b) This part does not apply to—

(1) LNG facilities used by ultimate consumers of LNG or natural gas.

(2) LNG facilities used in the course of natural gas treatment or hydrocarbon extraction which do not store LNG.

(3) In the case of a marine cargo transfer system and associated facilities, any matter pertaining to the system or facilities between the marine vessel and the last manifold (or in the absence of a manifold, the last valve) located immediately before a storage tank.

(4) Any LNG facility located in navigable waters (as defined in Section 3(8) of the Federal Power Act (16 U.S.C. 796(8)).

§ 193.2003 Semisolid facilities.

An LNG facility used in the transportation or storage of LNG in a semisolid state need not comply with any requirement of this part which the Director finds impractical or unnecessary because of the semisolid state of LNG. In making such a finding, the Director may impose appropriate alternative safety conditions.

§ 193.2005 Applicability

(a) New or amended standards in this part governing the siting, design, installation, or construction of an LNG facility and related personnel qualifications and training do not apply to—

(1) LNG facilities under construction before the date such standards are published; or

(2) LNG facilities for which an application for approval of the siting, construction, or operation was filed before March 1, 1978, with the Department of Energy (or any predecessor organization of that Department) or the appropriate State or local agency in the case of any facility not subject to the jurisdiction of the Department of Energy under the Natural Gas Act (not including any facility the construction of which began after November 29, 1979, not pursuant to such an approval).

(b) If an LNG facility listed in paragraph (a) of this section is replaced, relocated, or significantly altered after February 11, 1980, the replacement, relocated facility, or significantly altered facility must comply with the applicable requirements of this part governing siting, design, installation, and construction, except that—

(1) The siting requirements apply only to relocations of LNG storage tanks and to any replacement or significant alteration of LNG storage tanks that increases the storage capacity of the original facility; and

(2) To the extent compliance with the design, installation, and construction requirements would make the replaced, relocated, or altered facility incompatible with other facilities or would otherwise be impracticable, the replaced, relocated, or significantly altered facility may be designed, installed, or constructed in accordance with the original specifications for the facility, or in a manner that the Director finds acceptable.

(c) The siting, design, installation, and construction of an LNG facility that is under construction before February 11, 1980, or that is listed in paragraph (a)(2) of this section must meet the applicable requirements of § 192.12 of this chapter.

§ 193.2007 Definitions.

As used in this part—

"Ambient vaporizer" means a vaporizer which derives heat from naturally occurring heat sources, such as the atmosphere, sea water, surface waters, or geothermal waters.

"Cargo transfer system" means a component, or system of components functioning as a unit, used exclusively for transferring hazardous fluids in bulk between a tank car, tank truck, or marine vessel and a storage tank.

"Component" means an LNG facility for controlling, processing, or containing hazardous fluids or to provide safety.

"Container" means a component other than piping that contains a hazardous fluid.

"Control system" means a component, or system of components functioning as a unit, including control valves and sensing, warning, relief, shutdown, and other control devices, which is activated either manually or automatically to establish or maintain the performance of another component.

"Controllable emergency" means an emergency where reasonable and prudent action can prevent harm to people or property.

"Design pressure" means the pressure used in the design of components for the purpose of determining the minimum permissible thickness or physical characteristics of its various parts. When applicable, static head shall be included in the design pressure to determine the thickness of any specific part.

"Determine" means make an appropriate investigation using scientific methods, reach a decision based on sound engineering judgment, and be able to demonstrate the basis of the decision.

"Dike" means the perimeter of an impounding space forming a barrier to prevent liquid from flowing in an unintended direction.

"Director" means Director of the Materials Transportation Bureau or any person to whom authority in the matter concerned has been delegated.

"Emergency" means a deviation from normal operation, a structural failure, or severe environmental conditions that probably would cause harm to people or property.

"Exclusion zone" means an area surrounding an LNG facility in which an operator or government agency legally controls all activities in accordance with § 193.2057 and § 193.2059 for as long as the facility is in operation.

"Fail-safe" means a design feature which will maintain or result in a safe condition in the event of malfunction or failure of a power supply, component, or control device.

"g" means the standard acceleration of gravity of 9.806 metre per second^2 (32.17 feet per second^2).

"Gas," except when designated as inert, means natural gas, other flammable gas, or gas which is toxic or corrosive.

"Hazardous fluid" means gas or hazardous liquid.

"Hazardous liquid" means LNG or a liquid that is flammable or toxic.

"Heated vaporizer" means a vaporizer which derives heat from other than naturally occurring heat sources.

"Impounding space" means a volume of space formed by dikes and floors which is designed to confine a spill of hazardous liquid.

"Impounding system" includes an impounding space, including dikes and floors for conducting the flow of spilled hazardous liquids to an impounding space.

"Liquefied natural gas" or "LNG" means natural gas or synthetic gas having methane (CH_4) as its major constituent which has been changed to a liquid or semisolid.

"LNG facility" means a pipeline facility that is used in the process of liquefying or solidfying natural gas or synthetic gas or transferring, storing, or vaporizing liquefied natural gas.

"LNG plant" means an LNG facility or system of LNG facilities functioning as a unit.

"m^3" means a volumetric unit which is one cubic metre, 6.2898 barrels, 35.3147 ft.^{3}, or 264.1720 U.S. gallons, each volume being considered as equal to the other.

"Maximum allowable working pressure" means the maximum gage pressure permissible at the top of the equipment, containers or pressure vessels while operating at design temperature.

"Normal operation" means functioning within ranges of pressure, temperature, flow, or other operating criteria required by this part.

"Operator" means a person who owns or operates an LNG facility.

"Person" means any individual, firm, joint venture, partnership, corportation, association, state, municipality, cooperative association, or joint stock association and includes any trustee, receiver, assignee, or personal representative thereof.

"Pipeline facility" means new and existing piping, rights-of-way, and any equipment, facility, or building used in the transportation of gas or in the treatment of gas during the course of transportation.

"Piping" means pipe, tubing, hoses, fittings, valves, pumps, connections, safety devices or related components for containing the flow of hazardous fluids.

"Storage tank" means a container for storing a hazardous fluid, including an underground cavern.

"Transfer piping" means a system of permanent and temporary piping used for transferring hazardous fluids between any of the following: liquefaction process facilities, storage tanks, vaporizers, compressors, cargo transfer systems, and facilities other than pipeline facilities.

"Transer system" includes transfer piping and cargo transfer system.

"Vaporization" means an addition of thermal energy changing a liquid or semisolid to a vapor or gaseous state.

"Vaporizer" means a heat transfer facility designed to introduce thermal energy in a controlled manner for changing a liquid or semisolid to a vapor or gaseous state.

§ 193.2009 Rules of regulatory construction.

(a) As used in this part—

(1) "Includes" means including but not limited to;

(2) "May" means is permitted to or is authorized to;

(3) "May not" means is not permitted to or is not authorized to; and

(4) "Shall" or "must" is used in the mandatory and imperative sense.

(b) In this part—

(1) Words importing the singular include the plural; and

(2) Words importing the plural include the singular.

§ 193.2011 Reporting.

Leaks and spills of LNG must be reported in accordance with the requirements of Part 191 of this chapter.

§ 193.2013 Incorporation by reference.

(a) There are incorporated by reference in this Part all materials referred to in this Part that are not set forth in full. The incorporated materials are deemed published under 5 U.S.C. 552(a) and 1 CFR Part 51 and are part of this regulation as though set forth in full. All incorporated materials are listed in Appendix A to this Part 193 with the applicable editions in parentheses following the title of the referenced material. Only the latest listed edition applies, except that an earlier listed edition may be followed with respect to components which are designed, manufactured, or installed in accordance with the earlier edition before the latest edition is adopted, unless otherwise provided in this part. The incorporated materials are subject to change, but any change will be announced by publication in the Federal Register before it becomes effective.

(b) All incorporated materials are available for inspection in the Materials Transportation Bureau, U.S. Department of Transportation, 400 Seventh Street, SW., Washington, D.C. 20590, and at the Office of the Federal Register Library, 1100 L Street, NW., Washington, D.C. In addition, copies of the incorporated materials are available from the respective organizations listed in Appendix A to this Part 193.

(c) Incorporated by reference provisions approved by the Director of the Federal Register, February 4, 1980.

§ 193.2015 Petitions for finding or approval.

Where a rule in this part authorizes the Director to make a finding or approval, any operator may petition the Director to make such finding or approval. Petitions must be sent to the Director, Material Transportation Bureau, 400 Seventh Street, SW., Washington, D.C. 20590, and be received at least 90 days before the operator requests that the finding or approval be made. Each petition must refer to the rule-authorizing the action sought and contain information or arguments that justify the action. Unless otherwise specified, no public proceeding is held on a petition before it is granted or denied. The Director notifies the petitioner of the disposition of each petition.

Subpart B—Site-Related Design Requirements

§ 193.2051 Scope.

This subpart prescribes site-related requirements for the design of the following LNG facilities: containers and their impounding systems, transfer systems and their impounding systems, emergency shutdown control systems, fire control systems, and associated foundations, support systems, and normal or auxiliary power facilities necessary to maintain safety.

§ 193.2055 General.

An LNG facility must be located at a site of suitable size, topography, and configuration so that the facility can be designed to minimize the hazards to persons and offsite property resulting from leaks and spills of LNG and other hazardous fluids at the site. In selecting a site, each operator shall determine all site-related characteristics which could jeopardize the integrity and security of the facility. A site must provide ease of access so that personnel, equipment, and materials from offsite locations can reach the site for fire fighting or controlling spill associated hazards or for evacuation of personnel.

§ 193.2057 Thermal radiation protection.

(a) *Thermal exclusion zone.* Each LNG container and LNG transfer system must have a thermal exclusion zone in accordance with the following:

(1) Within the thermal exclusion zone, the impounding system may not be located closer to targets listed in paragraph (d) of this section than the exclusion distance "d" determined according to this section, unless the target is an LNG facility of the operator.

(2) If grading and drainage are used under § 193.2149(b), operators must comply with the requirements of this section by assuming the space needed for drainage and collection of spilled liquid is an impounding system.

(b) *Measurement.* The exclusion distance "d" is measured along the line (PT), as shown in the following impoundment diagram, where the following apply:

(1) T is a point on the target that is closest to (P).

(2) D is a point closest to (T) on the top inside edge of the innermost dike.

(3) θ is one of the following angles with the vertical, to account for flame tilt and potential preignition vapor formation:

(i) An assumed angle of $(\theta)=45°$; or

(ii) An angle determined in accordance with a mathematical model that meets the criteria of paragraph (c)(2) of this section, using the maximum wind speed that is exceeded less than 5 percent of the time based on recorded data for the area.

(4) L is one of the following lengths to account for flame height:

(i) An assumed length of $(L)=6(A/\pi)^{0.5}$, where (A) is the horizontal area across the impounding space measured at the lowest point along the top inside edge of the dike; or

(ii) A length determined in accordance with a mathematical model that meets the criteria of paragraph (c)(2) of this section, using appropriate parameters consistent with the time period that a target could be subjected to exposure before harm would result.

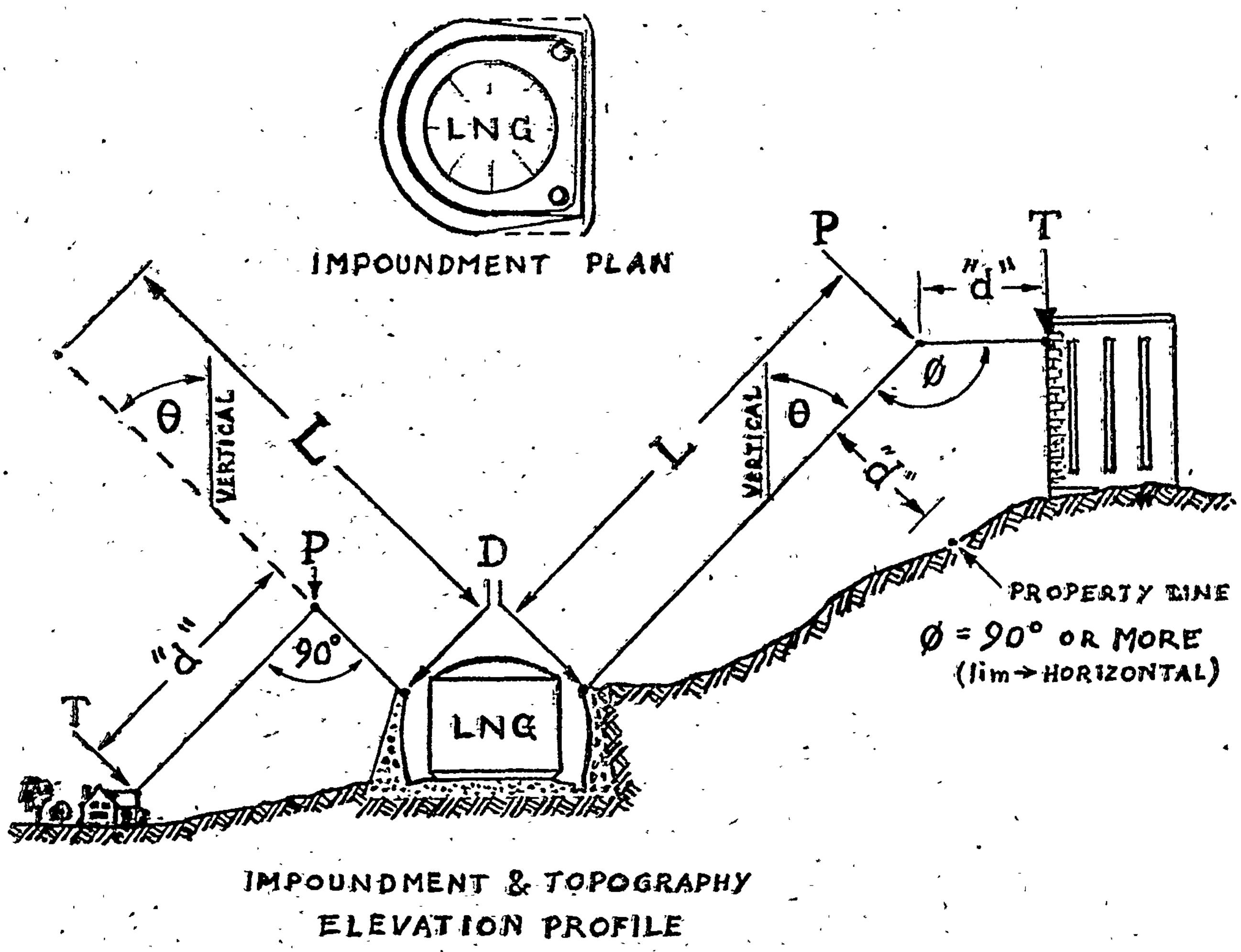
(5) PD is a line of length (L) or less, lying at angle θ in the vertical plane that intersects points (D) and (T).

(6) PT is a line lying in the vertical plane of line (PD), that:

(i) Is perpendicular to line (PD) when (PD) is less than (L); or

(ii) Has an angular elevation not above the horizontal at (P) when (PD) equals (L);

(7) P is the point where (PT) and (PD) intersect.



(c) *Exclusion distance length.* The length of an exclusion distance for each impounding space may not be less than the distance "d" determined in accordance with one of the following:

(1) $d=(f)(A)^{0.5}$, where

A=the largest horizontal area across the impounding space measured at the lowest point along the top inside edge of the dike.

f=values for targets prescribed in paragraph (d) of this section.

(2) Determine "d" from a mathematical model for thermal radiation and other appropriate fire characteristics which assures that the incident thermal flux levels in paragraph (d) of this section are not exceeded. The model must:

(i) Use atmospheric conditions which, if applicable, result in longer exclusion distances than other atmospheric conditions occurring at least 95 percent of the time based on recorded data for the site area;

(ii) Have been evaluated and verified by testing at a scale, considering scaling effects, appropriate for the range of application;

(iii) Have been submitted to the Director for approval, with supportive data as necessary to demonstrate validity; and

(iv) Have received approval by the Director.

(d) *Limiting values for incident radiant flux on offsite targets.* The maximum incident radiant flux at an offsite target from burning of a total spill in an impounding space must be limited to the distances in paragraph (c) of this section using the following values of "(f)" or "Incident Flux":

Offsite target	(f)	Incident flux Btu/ft.² hour
(1) Outdoor areas occupied by 20 or more persons during normal use, such as beaches, playgrounds, outdoor theaters, other recreation areas or other places of public assembly	(3)	1,600
(2) Buildings that are used for residences, or occupied by 20 or more persons during normal use	(1.6)	4,000
(3) Buildings made of cellulosic materials or are not fire resistant or do not provide durable shielding from thermal radiation that: (i) Have exceptional value, or contain objects of exceptional value based on historic uniqueness described in Federal, State, or local registers; (ii) Contain explosive, flammable, or toxic materials in hazardous quantities; or (iii) Could result in additional hazard if exposed to high levels of thermal radiation	(1.6)	4,000
(4) Structures that are fire resistant and provide durable shielding from thermal radiation that have the characteristics described in subdivisions (3)(i) through (3)(iii) above	(1.1)	6,700
(5) Public streets, highways, and mainlines of railroads	(1.1)	6,700
(6) Other structures, or if closer to (P), the property line of the facility	(0.8)	10,000

§ 193.2059 Flammable vapor-gas dispersion protection.

(a) *Dispersion exclusion zone.* Except as provided by paragraph (e) of this section, each LNG container and LNG transfer system must have a dispersion exclusion zone with a boundary described by the minimum dispersion distance computed in accordance with this section. The following are prohibited in a dispersion exclusion zone unless it is an LNG facility of the operator:

(1) Outdoor areas occupied by 20 or more persons during normal use, such as beaches, playgrounds, outdoor theaters, other recreation areas, or other places of public assembly.

(2) Buildings that are:

(i) Used for residences;

(ii) Occupied by 20 or more persons during normal use;

(iii) Contain explosive, flammable, or toxic materials in hazardous quantities;

(iv) Have exceptional value or contain objects of exceptional value based on historic uniqueness described in Federal, State, or local registers; or

(v) Could result in additional hazard if exposed to a vapor-gas cloud.

(b) *Measuring dispersion distance.* The dispersion distance is measured radially from the inside edge of an impounding system along the ground contour to the exclusion zone boundary.

(c) *Computing dispersion distance.* A minimum dispersion distance must be computed for the impounding system. If grading and drainage are used under § 193.2149(b), operators must comply with the requirements of this section by assuming the space needed for drainage and collection of spilled liquid is an impounding system. Dispersion distance must be determined in accordance with the following dispersion parameters, using applicable parts of the mathematical model in Appendix B of the report, "Evaluation of LNG Vapor Control Methods," 1974, or a model for vapor dispersion which meets the requirements of subdivisions (ii) through (iv) in § 193.2057(c)(2):

(1) Average gas concentration in air = 2.5 percent.

(2) Dispersion conditions are a

combination of those which result in longer predicted downwind dispersion distances than other weather conditions at the site at least 90 percent of the time, based on U.S. Government weather data, or as an alternative where the model used gives longer distances at lower wind speeds, Category F atmosphere, wind speed = 4.5 miles per hour, relative humidity equals 50.0 percent, and atmospheric temperatures = 0.0 C.

(3) Dispersion coordinates y, z, and H, where applicable, = 0.

(d) *Vaporization design rate.* In computing dispersion distance under paragraph (c) of this section, the following applies:

(1) Vaporization results from the spill caused by an assumed rupture of a single transfer pipe (or multiple pipes that lack provisions to prevent parallel flow) which has the greatest overall flow capacity, discharging at maximum potential capacity, in accordance with the following conditions:

(i) The rate of vaporization is not less than the sum of flash vaporization and vaporization from boiling by heat transfer from contact surfaces during the time necessary for spill detection, instrument response, and sequenced shutdown by the automatic shutdown system, but not less than 10 minutes, plus, in the case of side or bottom penetrations, any additional time necessary for the differential head acting on the opening to reach zero.

(ii) In determining variations in vaporization rate due to surface contact, the time necessary to wet 100 percent of the impounding floor area shall be determined by equation C-9 in the report "Evaluation of LNG Vapor Control Methods," 1974, or an alternate model which meets the requirements of subdivisions (ii) through (iv) in § 193.2057(c)(2).

(iii) After spill flow is terminated, the rate of vaporization is vaporization of the remaining spillage, if any, from boiling by heat transfer from contact surfaces that are reducing in area and temperature as a function of time.

(iv) Vapor detention space is all space provided for liquid impoundment and vapor detention outside the component served, less the volume occupied by the spilled liquid at the time the vapor escapes the vapor detention space.

(2) The boiling rate of LNG on which dispersion distance is based is determined using the weighted average value of the thermal properties of the contact surfaces in the impounding space determined from eight representative experimental tests on the materials involved. If surfaces are insulated, the insulation must be designed, installed, and maintained so that it will retain its performance characteristics under spill conditions.

(e) *Planned vapor control.* An LNG facility need not have a dispersion exclusion zone if the Director finds that compliance with paragraph (a) of this section would be impractical and the operator prepares and follows a plan for controlling LNG vapor that is found acceptable by the Director. The plan must include circumstances under which LNG vapor is controlled to preclude the dispersion of a flammable mixture from the LNG facility under all predictable environmental conditions that could adversely affect control. The reliability of the method of control must be demonstrated by testing or experience with LNG spills.

§ 193.2061 Seismic investigation and design forces.

(a) Except for shop fabricated storage tanks of 70,000 gallons or less capacity mounted within 2 feet of the ground, if an LNG facility is located at a site in Zone 0 or 1 of the "Seismic Risk Map of the United States," UBC, each operator shall determine, based on a study of faults, hydrologic regime, and soil conditions, whether a potential exists at the site for surface faulting or soil liquefaction.

(b) Subject to paragraph (f) of this section, LNG facilities must be designed and built to withstand, without loss of structural or functional integrity, the following seismic design forces, as applicable:

(1) For LNG facilities (other than shop fabricated storage tanks of 70,000 gallons or less capacity mounted within 2 feet of the ground) located at a site in Puerto Rico in Zone 2, 3, or 4 of the "Seismic Risk Map of the United States," or at a site determined under paragraph (a) of this section to have a potential for surface faulting or soil liquefaction, the forces that could reasonably be expected to occur at the foundation of the facility due to the most critical ground motion, motion amplification, permanent differential ground displacement, soil liquefaction, and symmetric and assymmetric reaction forces resulting from hydrodynamic pressure and motion of contained liquid in interaction with the facility structure.

(2) For all other LNG facilities, the total lateral force set forth in UBC, Volume 1, corresponding to the zone of the "Seismic Risk Map of the United States" in which the facility is located, and a vertical force equal to the total lateral force.

(c) Each operator of an LNG facility to which paragraph (b)(1) of this section applies shall determine the seismic design forces on the basis of a detailed geotechnical investigation and in accordance with paragraphs (d) and (e) of this section. The investigation must include each of the following items that could reasonably be expected to affect the site and be sufficient in scope to identify all hazards that could reasonably be expected to affect the facility design:

(1) Identification and evaluation of faults, Quaternary activity of those faults, tectonic structures, static and dynamic properties of materials underlying the site, and, as applicable, tectonic provinces within 100 miles of the site;

(2) Identification and evaluation of all historically reported earthquakes which could affect the determination under this section of the most critical ground motion or differential displacement at the site when correlated with particular faults, tectonic structures, and tectonic provinces, as applicable; and

(3) Identification and evaluation of the hydrologic regime and the potential of liquefaction-induced soil failures.

(d) The most critical ground motion must be determined in accordance with paragraph (e) of this section either:

(1) Probabilistically, when the available earthquake data are sufficient to show that the yearly probability of exceedance of most critical ground motion is 10^{-4} or less; or

(2) Deterministically, when the available earthquake data are insufficient to provide probabilistic estimates, with the objective of determining a most critical ground motion with a yearly probability of exceedance of 10^{-4} or less.

(e) The determination of most critical ground motion, considering local and regional seismological conditions, must be made by using the following:

(1) A regionally appropriate attenuation relationship, assuming that earthquakes occur at a location on a fault, tectonic structure, or tectonic province, as applicable, which would cause the most critical seismic movement at the site, except that where epicenters of historically reported earthquakes cannot be reasonably related to known faults or tectonic structures, but are recognized as being within a specific tectonic province

which is within 100 miles of the site, assume that those earthquakes occur within their respective provinces at a source closest to the site.

(2) A horizontal design response spectrum determined from the mean plus one standard deviation of a free-field horizontal elastic response spectra whose spectral amplitudes are consistent with values expected for the most critical ground motion.

(3) A vertical design response spectrum that is either two-thirds of the amplitude of the horizontal design response spectrum at all frequencies or equal to the horizontal design response spectrum where the site is located within 10 miles of the earthquake source.

(f) An LNG storage tank may not be located at a site where investigation under paragraph (c) of this section shows that—

(1) The estimated differential Quaternary fault displacement within 1 mile of the tank foundation exceeds 60 inches;

(2) The estimated design horizontal acceleration exceeds 0.8g at the tank foundation; or

(3) The potential for soil liquefaction cannot be accommodated by design and construction in accordance with paragraph (b)(1) of this section.

(g) Each container which does not have a structurally liquid-tight cover must have sufficient freeboard with an appropriate configuration to prevent the escape of liquid due to sloshing, wave action, and vertical liquid displacement caused by seismic action.

§ 193.2063 Flooding.

(a) Each operator shall determine the effects of flooding on an LNG facility site based on the worst occurrence in a 100-year period. The determination must take into account:

(1) Volume and velocity of the floodwater;

(2) Tsunamis (local, regional, and distant);

(3) Potential failure of dams;

(4) Predictable land developments which would affect runoff accumulation of water; and

(5) Tidal action.

(b) The effect of flooding determined under paragraph (a) of this section must be accommodated by location or design and construction, as applicable, to reasonably assure:

(1) The structural or functional integrity of LNG facilities; and

(2) Access from outside the LNG facility and movement of personnel and equipment about the LNG facility site for the control of fire and other emergencies.

§ 193.2065 Soil characteristics.

(a) Soil investigations including borings and other appropriate tests must be made at the site of each LNG facility to determine bearing capacity, settlement characteristics, potential for erosion, and other soil characteristics applicable to the integrity of the facility.

(b) The naturally occurring or designed soil characteristics at each LNG facility site must provide load bearing capacities, using appropriate safety factors, which can support the following loads without excessive lateral or vertical movement that causes a loss of the functional or structural integrity of the facility involved:

(1) Static loading caused by the facility and its contents and any hydrostatic testing of the facility; and

(2) Dynamic loading caused by movement of contents of the facility during normal operation, including flow, sloshing, and rollover.

§ 193.2067 Wind forces.

(a) LNG facilities must be designed to withstand without loss of structural or functional integrity:

(1) The direct effect of wind forces;

(2) The pressure differential between the interior and exterior of a confining, or partially confining, structure; and

(3) Impact forces and potential penetrations by wind borne missiles.

(b) The wind forces at the location of the specific facility must be based on one of the following:

(1) For shop fabricated containers of LNG or other hazardous fluids with a capacity of not more than 70,000 gallons, applicable wind load data in ANSI A 58.1, 1972 edition.

(2) For all other LNG facilities—

(i) Where adequate wind data are available, the most critical combination of wind velocity and duration with respect to the effect on a structure having a probability of exceedance in a 50-year period of 0.5 percent or less; or

(ii) Where adequate wind data are unavailable, an assumed sustained wind velocity of not less than 200 miles per hour, unless the Director finds a lower velocity is justified by adequate supportive data.

§ 193.2069 Other severe weather and natural conditions.

(a) In addition to the requirements of §§ 193.2061, 193.2063, 193.2065, and 193.2067, each operator shall determine from historical records and engineering studies the worst effect of other weather and natural conditions which may predictably occur at an LNG facility site.

(b) The facility must be located and designed so that such severe conditions cannot reasonably be expected to result in an emergency involving the factors listed in § 193.2063(b).

§ 193.2071 Adjacent activities.

(a) Each operator shall determine that present and reasonably foreseeable activities adjacent to an LNG facility site that could adversely affect the operation of the LNG facility or the safety of persons or offsite property, if damage to the facility occurs.

(b) An LNG facility must not be located where present or projected offsite activities would be reasonably expected to—

(1) Adversely affect the operation of any of its safety control systems;

(2) Cause failure of the facility; or

(3) Cause the facility not to meet the requirements of this part.

§ 193.2073 Separation of facilities.

Each LNG facility site must be large enough to provide for minimum separations between facilities and between facilities and the site boundary to—

(a) Permit movement of personnel, maintenance equipment, and emergency equipment around the facility; and

(b) Comply with distances specified in Sections 2-2.4 through 2-2.7 of NFPA 59A.

Subpart C—Design

§ 193.2101 Scope.

This subpart prescribes requirements for the selection and qualification of materials for components, and for the design and installation or construction of components and buildings, including separate requirements for impounding systems, LNG storage tanks, and transfer systems.

Materials

§ 193.2103 General.

Materials for all components must be—

(a) Able to maintain their structural integrity under all design loadings, including applicable environmental design forces under Subpart B of this part;

(b) Physically, chemically, and thermally compatible within design limits with any fluid or other materials with which they are in contact; and

(c) Qualified in accordance with the applicable requirements of this subpart.

§ 193.2105 Extreme temperatures; normal operations.

Each operator shall—

(a) Determine the range of temperatures to which components will be subjected during normal operations, including required testing, initial startup, cooldown operations, and shutdown conditions; and

(b) Use component materials that meet the design standards of this part for strength, ductility, and other properties throughout the entire range of temperatures to which the component will be subjected in normal operations.

§ 193.2107 Extreme temperatures, emergency conditions.

(a) Each operator shall determine the effects on components not normally exposed to extreme cold (including a component's foundation or support system) of contact by LNG or cold refrigerant that could result from error, a spill, or other emergency determined as required by this part.

(b) Each operator shall determine the effects on components (including their foundations or support systems) of the extreme heat which could result from an LNG or other hazardous fluid fire.

(c) Where the exposure determined under paragraph (a) or (b) of this section could result in a failure that would worsen the emergency, the component or its foundation or support system, as appropriate, must be:

(1) Made of material or constructed to be suitable for the extreme temperature to which it could be subjected; or

(2) Protected by insultation or other means that will delay failure due to extreme temperature in order to allow adequate time to take emergency responses.

(d) If a material that has low resistance to flame temperatures is used in any component containing a hazardous fluid, the material must be protected so that any heat resulting from a controllable emergency does not cause the release of fluid that would result in an uncontrollable emergency.

§ 193.2109 Insulation.

During normal operations, insulation materials must—

(a) Maintain insulating values;

(b) Withstand thermal and mechanical design loads; and

(c) Be covered with a material that is noncombustible in the installed state, is not subject to ultraviolet decay, and that can withstand the forces of wind according to ANSI A58.1 and anticipated loading which could occur in a controllable emergency.

§ 193.2111 Cold boxes.

All cold boxes must be made of noncombustible material and the insulation must be made of materials which are noncombustible in the installed condition.

§ 193.2113 Piping.

(a) Piping made of cast iron, malleable iron, or ductile iron may not be used to carry any cryogenic or hazardous fluids.

(b) Piping materials intended for normal use at temperatures below −28.9° C (−20° F) or for use under § 193.2107(c)(1) must be qualified by testing in accordance with ANSI B 31.3 to comply with § 193.2103(b).

§ 193.2115 Concrete subject to cryogenic temperatures.

Concrete intended for normal use at cryogenic temperatures or for use under § 193.2107(c)(1) may not be used unless—

(a) Materials, measurements, mixing, placing, prestressing, and poststressing of concrete meets generally accepted engineering practices;

(b) Metallic reinforcing, prestressing wire, structural and nonstructural members used in concrete are acceptable in the installed condition for the temperature and stress levels encountered at design loading conditions; and

(c) Tests for the compressive strength, the coefficient of contraction, an acceptable thermal gradient, and, if applicable, acceptable surface loading to prevent detrimental spalling are performed on the concrete at the lowest temperature for which the concrete is designed or similar test data on these properties are available.

§ 193.2117 Combustible materials.

Combustible materials are not permitted for the construction of buildings, plant equipment, and the foundations and supports of buildings and plant equipment in areas where ignition of the material would worsen an emergency. However, limited combustible materials may be used when the use of noncombustible materials is impractical.

§ 193.2119 Records

Each operator shall keep a record of all materials for components, buildings, foundations, and support systems, as necessary to verify that material properties meet the requirements of this part. These records must be maintained for the life of the item concerned.

Design of Components and Buildings

§ 193.2121 General.

Components, including their foundations and support systems, must be designed, fabricated, and installed to withstand, without loss of functional or structural integrity, predictable loadings not including environmental design forces under Subpart B of this part unless applicable under that subpart.

§ 193.2123 Valves.

(a) Each valve, including control valves and relief valves, must be designed, manufactured, and tested to comply with ANSI B31.3 or ANSI B31.5 or ANSI B31.8 or API Standard 6D, if design conditions fall within their scope.

(b) Extended bonnet valves must be used for service temperatures below −45.6° C (−50° F).

(c) Valves used for cryogenic liquid service must be designed to operate in the position in which they are installed.

(d) Powered local and remote operation must be provided for valves that would be difficult or excessively time-consuming to manually operate during a controllable emergency.

(e) Valves must be designed and installed so that an excessive load on the piping system does not render the valve inoperable.

§ 193.2125 Automatic shutoff valves.

Each automatic shutoff valve or combination of valves must—

(a) Have a fail-safe design;

(b) Operate to stop fluid flow which would endanger the operational integrity of plant equipment; and

(c) Close at a rate to avoid fluid hammer which would endanger the operating integrity of a component.

§ 193.2127 Piping.

(a) Piping must be designed, manufactured, and tested to comply with ANSI B 31.3.

(b) All cryogenic and hazardous fluid piping must have connections to facilitate blowdown and purge as required by this part.

(c) Each cryogenic or hazardous fluid piping system that is aboveground must be identified by color coding, painting, or labeling.

(d) Seamless pipe or pipe with a longitudinal joint efficiency of 1.0 determined in accordance with ANSI B31.3, or pipe with a design pressure less than two-thirds of the mill-proof test pressure or subsequent shop or field hydrostatic test pressure must be used for process and transfer piping handling cryogenic or other hazardous fluids with a service temperature below −22° F (−30° C).

(e) For longitudinal or spiral weld piping handling LNG or cryogenic fluids, the heat affected zone must comply with § 323.2.2 of ANSI B31.3.

(f) Threaded piping used in hazardous fluid service must be at least Schedule 80.

§ 193.2129 Piping attachments and supports.

Piping attachments and supports for LNG or refrigerant piping must be designed to prevent excessive heat transfer which can result in either unintentional restraint of piping caused by ice formations or the embrittlement of supporting steel.

§ 193.2131 Building design.

(a) Each building or structural enclosure in which potentially hazardous quantities of flammable materials are handled must be designed and constructed to minimize fire hazards.

(b) Buildings or structural enclosures in which hazardous or cryogenic fluids are handled shall be of light-weight, noncombustible construction with nonload-bearings walls.

(c) If rooms containing such fluids are located within or attached to buildings in which such fluids are not handled, i.e., control rooms, shops, etc., the common walls shall be limited to not more than two in number, shall be designed to withstand a static pressure of at least 4800 Pa (100 psf), have no doors or other communicating openings, and shall have a fire resistance rating of at least 1 hour.

§ 193.2133 Buildings; ventilation.

(a) Each building in which potentially hazardous quantities of flammable fluids are handled must be ventilated to minimize the possibility, during normal operation, of hazardous accumulation of a flammable gas and air mixture, hazardous products of combustion, and other hazardous vapors in enclosed process areas by one of the following means:

(1) A continuously operating mechanical ventilation system;

(2) A combination gravity ventilation system and normally off mechanical ventilation system which is activated by suitable flammable gas detectors at a concentration not exceeding 25 percent of the lower flammable limit of the gas;

(3) a dual rate mechanical ventilation system with the high rate activated by suitable flammable gas detectors at a concentration not exceeding 25 percent of the lower flammable limit of the gas; or

(4) A gravity ventilation system composed of a combination of wall openings, roof ventilators, and, if there are basements or depressed floor levels, a supplemental mechanical ventilation system.

(b) The ventilation rate must be at least 1 cubic foot per minute of air per square foot of floor area. If vapors heavier than air can be present, the ventilation must be proportioned according to the area of each level.

§ 193.2135 Expansion or contraction.

Each operator shall consider the amount of contraction and expansion of each component during operating and environmental thermal cycling and shall—

(a) Provide components that operate without detrimental stress or restriction of movement, within each component and between components, caused by contraction and expansion; and

(b) Prevent ice buildup from detrimentally restricting the movement of components caused by contraction and expansion.

§ 193.2137 Frost heave.

(a) Each operator shall—

(1) Determine which components and their foundations could be endangered by frost heave from ambient temperatures or operating temperatures of the component; and

(2) Provide protection against frost heave which might impair their structural integrity.

(b) For each component and foundation determined under paragraph (a) of this section, instrumentation must be installed to warn of potential structural impairment due to frost heave, unless the operator includes in the maintenance procedures required by this part, a method and schedule of inspection that will detect changes in the elevation.

§ 193.2139 Ice and snow.

(a) Components must be designed to support the weight of ice and snow which could normally collect or form on them.

(b) Each operator shall provide protection for components from falling ice or snow which may accumulate on structures.

(c) Valves and moving components must not become inoperative due to ice formation on the component.

§ 193.2141 Electrical systems.

(a) Each operator shall select and install electrical equipment and wiring for components in accordance with NFPA-70 and, where applicable Section 7-62 of NFPA-59A.

(b) Electrical grounding and bonding must be in accordance with Section 7-7.1.1 of NFPA-59A.

(c) Protective measures for stray or impressed currents must be provided in accordance with Section 7-7.3 of NFPA-59A.

§ 193.2143 Lightning.

Each operator shall install proper grounds as necessary to minimize the hazard to plant personnel and components, including all electrical circuits, as a result of lightning.

§ 193.2145 Boilers and pressure vessels.

Boilers must be designed and fabricated in accordance with Section I or Section IV of the ASME Boiler and Pressure Vessel Code. Other pressure vessels subject to that Code must be designed and fabricated in accordance with Division 1 or Division 2 of Section VIII.

§ 193.2147 Combustion engines and turbines.

Combustion engines and gas turbines must be installed in accordance with NFPA-37.

Impoundment Design and Capacity

§ 193.2149 Impoundment required.

(a) An impounding system must be provided for storage tanks to contain a potential spill of LNG or other hazardous liquid.

(b) Grading or drainage or an impounding system must be provided to ensure that accidental spills or leaks from the following components and areas do not endanger components or adjoining property or enter navigable waterways:

(1) Liquefaction and other process equipment;

(2) Vaporizers;

(3) Transfer systems;

(4) Parking areas for tank cars or tank trucks; and

(5) Areas for loading, unloading, or storing portable containers and dewar vessels.

(c) Impounding systems for LNG must be designed and constructed in accordance with this subpart. Impounding systems intended for containment of hazardous liquids other than LNG must meet the requirements of NFPA-30.

§ 193.2151 General design characteristics.

(a) An impounding system must have a configuration or design which, to the maximum extent possible, will prevent liquid from escaping impoundment by leakage, splash from collapse of a structure or part thereof, momentum and low surface friction, foaming, failure of pressurized piping, and accidental pumping.

(b) The basic form of an impounding system may be excavation, a natural geological formation, manufactured diking, such as berms or walls, or any combination thereof.

§ 193.2153 Classes of impounding systems.

(a) For the purpose of this part, impounding systems are classified as follows:

Class 1. A system which surrounds the component served with the inner surface of the dike constructed against or within 24 inches of the component served.

Class 2. A system which surrounds the component or area served with the dike located a distance away from the component or at the periphery of the area.

Class 3. A system which conducts a spill by dikes and floors to a remote impounding space which does not surround the component or area served.

(b) In the case of an impounding system consisting of a combination of classes, requirements of this part regarding a single class apply according to the percentage of impoundment provided by each class.

§ 193.2155 Structural requirements.

(a) Subject to paragraph (b) of this section, the structural parts of an impounding system must be designed and constructed to prevent impairment of the system's performance reliability and structural integrity as a result of the following:

(1) The imposed loading from—

(i) Full hydrostatic head of impounded LNG;

(ii) Hydrodynamic action, including the effect of any material injected into the system for spill control;

(iii) The impingement of the trajectory of an LNG jet discharged at any predictable angle; and

(iv) Anticipated hydraulic forces from a credible opening in the component or item served, assuming that the discharge pressure equals design pressure.

(2) The erosive action from a spill, including jetting of spilling LNG, and any other anticipated erosive action including surface water runoff, ice formation, dislodgement of ice formation, and snow removal.

(3) The effect of the temperature, any thermal gradient, and any other anticipated degradation resulting from sudden or localized contact with LNG.

(4) Exposure to fire from impounded LNG or from sources other than impounded LNG.

(5) If applicable, the potential impact and loading on the dike due to—

(i) Collapse of the component or item served or adjacent components; and

(ii) If the LNG facility adjoins the right-of-way of any highway or railroad, collision by or explosion of a train, tank car, or tank truck that could reasonably be expected to cause the most severe loading.

(b) For spills from LNG storage tanks with Class 2 or 3 impounding systems, imposed loading and surging flow characteristics must be based on a credible release of the tank contents.

(c) If an LNG storage tank is located within a horizontal distance of 6,100 m. (20,000 ft.) from the nearest point of the nearest runway serving large aircraft as defined in 14 CFR Part 1.1, a Class 1 impounding system must be used which is designed to withstand collision by, or explosion of, the heaviest aircraft which can take off or land at the airport.

§ 193.2157 Coatings and coverings.

Insulation, sealants, or other coatings and coverings which are part of an impounding system—

(a) Must be noncombustible in an installed condition when exposed to an LNG fire resulting from a spill that covers the floor of the impounding space;

(b) Must withstand exposure to fire from sources determined as required by this part, other than impounded LNG, for a period of time until fire protective or fire extinguishing action is taken; and

(c) When used for the purpose of maintaining the functional integrity of an impounding system, must be capable of withstanding sudden exposure to LNG without loss of such integrity.

§ 193.2159 Floors.

Floors of Class 2 and Class 3 impounding systems must, to the extent feasible—

(a) Slope away from the component or item impounded and to a sump basin installed under § 193.2171;

(b) Slope away from the nearest adjacent component;

(c) Drain surface waters from the floor at rates based on a storm of 10-year frequency and 1-hour duration and other natural water sources; and

(d) Be designed to minimize the wetted floor area.

§ 193.2161 Dikes, general.

(a) Penetrations in dikes to accommodate piping or any other purpose are prohibited.

(b) An outer wall of a component served by an impounding system may not be used as a dike except for a concrete wall designed to comply with the requirements of § 193.2155(c) or equivalent design impact loading.

§ 193.2163 Vapor barriers.

If vapor barriers are installed in meeting the requirements of § 193.2059, they must be designed and constructed to detain LNG vapor.

§ 193.2165 Dike dimensions.

In addition to dike dimensions needed to comply with other requirements of this subpart, to minimize the possibility that a trajectory of accidentally discharged liquid would pass over the top of a dike, the distance from the inner wall of the component or vessel served to the closest inside edge of the top of the dike must at least equal the vertical distance from the maximum liquid level impounded to the inside edge of the top of the dike.

§ 193.2167 Covered systems.

(a) A covered impounding system is prohibited unless it is—

(1) Sealed from the atmosphere and filled with an inert gas; or

(2) Permanently interconnected with the vapor space of the component served.

(b) Flammable nonmetallic membranous covering is prohibited in a covered system.

(c) For systems to which paragraph (a)(1) of this section applies, instrumentation and controls must be provided to—

(1) Maintain pressures at a safe level; and

(2) Monitor gas concentrations in accordance with § 193.2169.

(d) Dikes must have adequate structural strength to assure that they can withstand impact from a collapsed cover and all anticipated conditions which could cause a failure of the impounding space cover.

§ 193.2169 Gas leak detection.

Appropriate areas within an impounding system where collection or passage of LNG or LNG vapor could be expected must be equipped with sensing and warning devices to monitor continuously for the presence of LNG or LNG vapor and to warn before LNG gas concentration levels exceed 25 percent of the lower flammable limit.

§ 193.2171 Sump basins.

Except for Class 1 impounding systems, a sump basin must be located in each impounding system for collection of water.

§ 193.2173 Water removal.

(a) Except for Class 1 systems, impounding systems must have sump pumps and piping running over the dike to remove water collecting in the sump basin.

(b) The water removal system must have adequate capacity to remove water at rates which equal the maximum predictable collection rate from a storm of 10-year frequency and 1-hour duration, and other natural causes.

(c) Sump pumps for water removal must—

(1) Be operated as necessary to keep the impounding space as dry as practical; and

(2) If sump pumps are designed for automatic operation, have redundant automatic shutdown controls to prevent operation when LNG is present.

§ 193.2175 Shared impoundment.

When an impounding system serves more than one component, tank car, tank truck, or dewar vessel, a means must be provided to prevent low temperature or fire resulting from leakage from any one of the items served causing any other item to leak. If § 193.2059(a) applies, the means must not result in a vapor dispersion distance which exceeds the exclusion zone.

§ 193.2179 Impoundment capacity; general.

In addition to capacities otherwise required by this subpart, an impounding system must have sufficient volumetric capacity to provide for—

(a) Displacement by the component, tank car, tank truck, container, or dewar vessel served; and

(b) Where applicable, displacement which could occur when a higher density substance than the liquid to be impounded enters the system, considering all relevant means of assuring capacity.

§ 193.2181 Impoundment capacity, LNG storage tanks.

(a) Except as provided in paragraph (b) of this section, each impounding system serving an LNG storage tank must have a minimum volumetric liquid impoundment capacity as follows:

Number of tanks in system	Class or type of system	System capacity in percent of LNG tank's maximum liquid capacity
1	Class 1	110 percent.
	Classes 2 and 3	150 percent.
More than 1	Classes 2 and 3	100 percent of all tanks or 150 percent of largest tank, whichever is greater.

(b) For purposes of this section, a covered impounding system serving a single LNG storage tank may have a capacity of 110 percent of the LNG tank's maximum liquid capacity if it is covered by a roof that is separate and independent from the LNG storage tank.

§ 193.2183 Impoundment capacity; equipment and transfer systems.

If an impounding system serves a component under § 193.2149(b) (1)–(3), it must have a minimum volumetric liquid impoundment capacity equal to the sum of—

(a) One-hundred percent of the volume of liquid that could be contained in the component and, where applicable, tank car or tank truck served; and

(b) The maximum volume of liquid which could discharge into the impounding space from any single failure of equipment or piping during the time period necessary for spill detection, instrument response, and sequenced shutdown by the automatic shutdown system under § 193.2439.

§ 193.2185 Impoundment capacity; parking areas, portable containers.

Each impounding system serving an area listed under § 193.2149(b) (4) or (5) must have a minimum volumetric liquid impoundment capacity which complies with the requirements of § 193.2181, assuming each tank car, tank truck, portable container, or dewar vessel to be a storage tank.

LNG Storage Tanks

§ 193.2187 General.

(a) LNG storage tanks must comply with the requirements of this subpart and the other applicable requirements of this part.

(b) A flammable nonmetallic membrane liner may not be used as an inner container in a storage tank.

§ 193.2189 Loading forces.

Each part of an LNG storage tank must be designed to withstand without loss of functional or structural integrity any predictable combination of forces which would result in the highest stress to the part, including the following:

(a) Internal design pressure determined under § 193.2197.

(b) External design pressure determined under § 193.2199.

(c) Weight of the structure.

(d) Weight of liquid to be stored, except that in no case will the density assumed be less than 29.3 pounds per cubic foot (470 kilograms per cubic meter).

(e) Loads due to testing required by § 193.2327.

(f) Nonuniform reaction forces on the foundation due to predictable settling and other movement.

(g) Superimposed forces from piping, stairways, and other connected appurtenances.

(h) Predictable snow and ice loads.

(i) The loading of internal insulation on the inner container and outer shell due to compaction and movement of the container and shell over the design life of the insulation.

(j) In the case of vacuum insulation, the forces due to the vacuum.

(k) In the case of a positive pressure purge, the forces due to the maximum positive pressure of the purge gas.

§ 193.2191 Stratification.

LNG storage tanks with a capacity of 5,000 barrels or more must be equipped with means to mitigate a potential for rollover and overpressure such as:

(a) Selective filling at the top and bottom of the tank;

(b) Circulating liquid from the bottom to the top of the same tank; or

(c) Transferring liquid selectively from the bottom of the tank to the bottom or top of any adjacent storage tank.

§ 193.2193 Movement and stress.

(a) Each operator shall determine for normal operations of each LNG storage tank—

(1) The amount and pattern of predictable movement of components, including transfer piping, and the foundation, which could result from thermal cycling, loading forces, and ambient air changes; and

(2) For a storage tank with an inner container, the predictable movement of the inner container and the outer shell in relation to each other.

(b) Storage tanks must be designed to provide adequate allowance for stress due to movement determined under paragraph (a) of this section, including provisions that—

(1) Backfill does not cause excessive stresses on the tank structure due to expansion of the storage tank during warmup;

(2) Insulation does not settle to a damaging degree or unsafe condition during thermal cycling; and

(3) Expansion bends and other expansion or contraction devices are adequate to prevent excessive stress on tank penetrations, especially during cooldown from ambient temperatures.

§193.2195 Penetrations.

(a) All penetrations in an LNG storage tank must be designed in accordance with API 620, including Appendix Q.

(b) The loadings on all penetrations must be determined by an analysis of all contributing forces, including those from tank thermal movements, connecting piping thermal movements, hydraulic forces, applicable wind and earthquake forces, and the forces resulting from settlement or movement of the tank foundation or pipe supports.

(c) All penetrations in an LNG storage tank below the design liquid level must be fitted with an internal shutoff valve which is designed and installed so that any failure of the nozzle penetrating the tank will be outside the tank.

(d) The requirements of paragraphs (a) and (c) of this section do not apply to shop fabricated tanks of 70,000 gallons or less capacity. All penetrations in such tanks must be designed and installed in accordance with the applicable provisions of Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code.

§ 193.2197 Internal design pressure.

(a) Each operator shall establish the internal design pressure at the top of each LNG storage tank, including a suitable margin above the maximum allowable working pressure.

(b) The internal design pressure of a storage tank may not be lower than the highest pressure in the vapor space resulting from each of the following events or combination thereof that predictably might occur, giving consideration to vapor handling equipment, relief devices in accordance with § 193.2429, and any other mitigating measures:

(1) Filling the tank with LNG including effects of increased vaporization rate due to superheat and sensible heat of the added liquid;

(2) Rollover.

(3) Fall in barometric pressure, using the worst combination of amount of fall and rate of fall which might predictably occur;

(4) Loss of effective insulation that may result from an adjacent fire, leak of liquid into the intertank space, or other predictable accident; and

(5) Flash vaporization resulting from pump recirculation.

§ 193.2199 External design pressure.

(a) Each operator shall establish the external design pressure at the top of each LNG storage tank, including a suitable margin below the minimum allowable working pressure.

(b) The external design pressure may not be higher than the lowest vapor pressure in the vapor space resulting from each of the following events or combinations thereof that predictably might occur, giving consideration to gas makeup systems, vacuum relief devices in accordance with § 193.2429, and any other mitigating measures.

(1) Withdrawing liquid from the tank;

(2) Withdrawing gas from the tank;

(3) Adding subcooled LNG to the tank; and

(4) Rise in barometric pressure, based on the worst combination of amount of rise and rate of rise which predictably might occur.

§ 193.2201 Internal temperature.

The liquid container of each LNG storage tank and all tank parts used in contact with LNG or its cold vapor shall be designed for the lowest bulk liquid temperature which can be attained in the LNG storage tank.

§ 193.2203 Foundation.

(a) Each LNG storage tank must have a stable foundation designed in accordance with generally accepted structural engineering practices.

(b) Each foundation must support design loading forces without detrimental settling that could impair the structural integrity of the tank.

§ 193.2205 Frost heave.

If the protection provided for LNG storage tank foundations from frost heave under § 193.2137(a) includes heating the foundation area—

(a) An instrumentation and alarm system must be provided to warn of malfunction of the heating system; and

(b) A means to correct the malfunction must be provided.

§ 193.2207 Insulation.

(a) Insulation on the outside of the outer shell of an LNG storage tank may not be used to maintain stored LNG at an operating temperature during normal operation.

(b) Insulation between an inner container and the outer shell of an LNG storage tank must—

(1) Be compatible with the contained liquid and its vapor;

(2) In its installed condition, be noncombustible; and

(3) Not significantly lose insulating properties by melting, settling, or other means due to a fire resulting from a spill that covers the floor of the impounding space around the tank.

§ 193.2209 Instrumentation for LNG storage tanks.

(a) Each LNG storage tank having a capacity over 70,000 gallons must be equipped with a sufficient number of sensing devices and personnel warning devices, as prescribed, which operate continuously while the tank is in operation to assure that each of the following conditions is not a potential hazard to the structural integrity or safety of the tank:

Condition	Instrumentation
(1) Amount of liquid in the tank.	Redundant liquid level gages and recorders with high level alarms, and a minimum of one independent high level alarm.
(2) Vapor pressure within the tank.	Redundant gages and recorders with high and low pressure alarms.
(3) Temperatures at representative critical points in the foundation.	Temperature indicating and recording devices with alarm.
(4) Temperature of contained liquid at various vertical intervals.	Temperature recorders.
(5) Abnormal temperature in tank structure.	Thermocouples located at representative critical points with recorders.
(6) Excessive relative movement of inner container and outer shell.	Linear and rotational movement indicators located between inner container and outer shell with recorders.

(b) LNG storage tanks with a capacity of 70,000 gallons or less must be equipped with the following:

(1) LNG liquid trycocks, when attended during the filling operation.

(2) Pressure gages and recorders with high pressure alarm.

(3) Differential pressure liquid level gage.

(c) Each storage tank must be designed as appropriate to provide for compliance with the inspection requirements of this part.

§ 193.2211 Metal storage tanks.

(a) Metal storage tanks with internal design pressures of not more than 15 psig must be designed and constructed in accordance with API Standard 620 and, where applicable, Appendix Q of that standard.

(b) Metal storage tanks with internal design pressures above 15 psig must be designed in accordance with the applicable division of Section VIII of the ASME Boiler and Pressure Vessel Code.

§ 193.2213 Concrete storage tanks.

Concrete storage tanks must be designed and constructed in accordance with Section 4-3 of NFPA-59A.

§ 193.2215 Thermal barriers.

Thermal barriers must be provided between piping and an outer shell when necessary to prevent the outer shell from being exposed during normal operation to temperatures lower than its design temperature.

§ 193.2217 Support system.

(a) Saddles and legs must be designed in accordance with generally accepted structural engineering practices, taking into account loads during transportation, erection loads, and thermal loads.

(b) Storage tank stress concentrations from support systems must be minimized by distribution of loads using pads, load rings, or other means.

(c) For a storage tank with an inner container, support systems must be designed to—

(1) Minimize thermal stresses imparted to the inner container and outer shell from expansion and contraction; and

(2) Sustain the maximum applicable loading from shipping and operating conditions.

(d) LNG storage tanks with an air space beneath the tank bottom or its foundation must be designed to withstand without loss of functional or structural integrity, the forces caused by the ignition of a combustible vapor cloud in this space.

§ 193.2219 Internal piping.

Piping connected to an inner container that is located in the space between the inner container and outer shell must be designed for not less than the pressure rating of the inner container. The piping must contain expansion loops where necessary to protect against thermal and other secondary stresses created by operation of the tank. Bellows may not be used within the space between the inner container and outer shell.

§ 193.2221 Marking.

(a) Each operator shall install and maintain a name plate in an accessible place on each storage tank and mark it in accordance with the applicable code or standard incorporated by reference in §§ 193.2211 or 193.2213.

(b) Each penetration in a storage tank must be marked indicating the function of the penetration.

(c) Marking required by this section must not be obscured by frosting.

Design of Transfer Systems

§ 193.2223 General.

(a) Transfer systems must comply with the requirements of this subpart and other applicable requirements of this part.

(b) The design of transfer systems must provide for stress due to the frequency of thermal cycling and intermittent use to which the transfer system may be subjected.

(c) Slip type expansion joints are prohibited and packing-type joints may not be used in transfer systems for LNG or flammable refrigerants.

(d) A suitable means must be provided to precool the piping in a manner that prevents excessive stress prior to normal transfer of cold fluids.

(e) Stresses due to thermal and hydraulic shock in the piping system must be determined and accommodated by design to avoid damage to piping.

§ 193.2227 Backflow.

(a) Each transfer system must operate with a means to—

(1) Prevent backflow of liquid from a receiving container, tank car, or tank truck from causing a hazardous condition; and

(2) Maintain one-way flow where necessary for the integrity or safe operation of the LNG facility.

(b) The means provided under paragraph (a)(1) of this section must be located as close as practical to the point of connection of the transfer system and the receiving container, tank car, or tank truck.

§ 193.2229 Cargo transfer systems.

(a) Each cargo transfer system must have—

(1) A means of safely depressurizing and venting that system before disconnection;

(2) A means to provide for safe vapor displacement during transfer;

(3) Transfer piping, pumps, and compressors located or protected by suitable barriers so that they are safe from damage by tank car or tank truck movements;

(4) A signal light at each control location or remotely located pumps or compressors used for transfer which indicates whether the pump or compressor is off or in operation; and

(5) A means of communication between loading or unloading areas and other areas in which personnel are associated with the transfer operations.

(b) Hoses and arms for cargo transfer systems must be designed as follows—

(1) The design must accommodate operating pressures and temperatures encountered during the transfers;

(2) Hoses must have a bursting pressure of not less than five times the operating pressure.

(3) Arms must meet the requirements of ANSI B31.3.

(4) Adequate support must be provided, taking into account ice formation.

(5) Couplings must be designed for the frequency of any coupling or uncoupling.

§ 193.2231 Cargo transfer area.

The transfer area of a cargo transfer system must be designed—

(a) To accommodate tank cars and tank trucks without excessive maneuvering; and

(b) To permit tank trucks to enter or exit the transfer area without backing.

§ 193.2233 Shutoff valves.

(a) Shutoff valves on transfer systems must be located—

(1) On each liquid supply line, or common line to multiple supply lines, to a storage tank, or to a cargo transfer system;

(2) On each vapor or liquid return line from multiple return lines, used in a cargo transfer system;

(3) At the connection of a transfer system with a pipeline subject to Part 192 of this chapter; and

(4) To provide for proper operation and maintenance of each transfer system.

(b) Transfer system shutoff valves that are designated for operation in the emergency procedures must be manually operable at the valve and power operable at the valve and at a remote location at least 50 feet from the valve.

Subpart D—Construction

§ 193.2301 Scope.

This subpart prescribes requirements for the construction or installation of components.

§ 193.2303 Construction acceptance.

No person may place in service any component until it passes all applicable inspections and tests prescribed by this subpart.

§ 193.2305 Procedures.

(a) In performing construction, installation, inspection, or testing, an operator must follow written specifications, procedures, and drawings, as appropriate, that are consistent with this part, taking into account relevant mechanical, chemical, and thermal properties, component functions, and environmental effects that are involved.

(b) All procedures, including any field revisions, must be substantiated by testing or experience to produce a component that is reliable and complies with the design and installation requirements of this part.

§ 193.2307 Inspection.

(a) All construction, installation, and testing activities must be inspected as frequently as necessary in accordance with a written plan to assure that—

(1) Activities are in compliance with all applicable requirements of this subpart; and

(2) Components comply with the applicable material, design, fabrication, installation, and construction requirements of this part.

(b) In addition to the requirements of paragraph (a) of this section, the construction of concrete storage tanks must be inspected in accordance with ACI-311-75.

(c) Each operator shall have a quality assurance inspection program to verify that components comply with their design specifications and drawings, including any field design changes, before they are placed in service.

§ 193.2309 Inspection and testing methods

Except as otherwise provided by this subpart, each operator shall determine, commensurate with the hazard that would result from failure of the component concerned, the scope and nature of—

(a) Inspections and tests required by this subpart; and

(b) Inspection and testing procedures required by § 193.2305.

§ 193.2311 Cleanup.

After construction or installation, as the case may be, all components must be cleaned to remove all detrimental contaminants which could cause a hazard during operation, including the following:

(a) All flux residues used in brazing or soldering must be removed from the joints and the base metal to prevent corrosive solutions from being formed.

(b) All solvent type cleaners must be tested to ensure that they will not damage equipment integrity or reliability.

(c) Incompatible chemicals must be removed.

(d) All contaminants must be captured and disposed of in a manner that does not reduce the effectiveness of corrosion protection and monitoring provided as required by this part.

§ 193.2313 Pipe welding.

(a) Each operator shall provide the following for welding on pressurized piping for LNG and other hazardous fluids:

(1) Welding procedures and welders qualified in accordance with Section IX of the ASME Boiler and Pressure Vessel Code or API 1104, as applicable;

(2) When welding materials that are qualified by impact testing, welding procedures selected to minimize degradation of low temperature properties of the pipe material; and

(3) When welding attachments to pipe, procedures and techniques selected to minimize the danger of burn-throughs and stress intensification.

(b) Oxygen fuel gas welding is not permitted on flammable fluid piping with a service temperature below −20°C (−22°F).

(c) Marking materials for identifying welds on pipe must be compatible with the basic pipe material.

(d) Surfaces of components that are less than 6.35 mm (0.25 in.) thick may not be field die stamped.

(e) Where die stamping is permitted, any identification marks must be made with a die having blunt edges to minimize stress concentration.

§ 193.2315 Piping connections.

(a) Piping more than 2 inches nominal diameter must be joined by welding, except that—

(1) Threaded or flanged connections may be used where necessary for special connections, including connections for material transitions, instrument connections, testing, and maintenance;

(2) Copper piping in nonflammable service may be joined by silver brazing; and

(3) Material transitions may be made by any joining technique proven reliable under § 193.2305(b).

(b) If socket fittings are used, a clearance of 1.6 to 3.2 mm (0.063 to 0.126 in.) between the pipe end and the bottom of the socket recess must be provided and appropriate measurement reference marks made on the piping for the purpose of inspection.

(c) Threaded joints must be—

(1) Free of stress from external loading; and

(2) Seal welded, or sealed by other means which have been tested and proven reliable.

(d) Compression type couplings must meet the requirements of ANSI B31.3.

(e) Care shall be taken to ensure the tightness of all bolted connections. Spring washers or other such devices designed to compensate for the contraction and expansion of bolted connections during operating cycles shall be used where required.

(f) The selection of gasket material shall include the consideration of fire.

§ 193.2317 Retesting.

After testing required by this subpart is completed on a component to contain a hazardous fluid, the component must be retested whenever—

(a) Penetration welding other than tie-in welding is performed; or

(b) The structural integrity of the component is disturbed.

§ 193.2319 Strength tests.

(a) A strength test must be performed on each piping system and container to determine whether the component is capable of performing its design function, taking into account—

(1) The maximum allowable working pressure;

(2) The maximum weight of product which the component may contain or support;

(b) For piping, the test required by paragraph (a) of this section must include a pressure test conducted in accordance with Section 337 of ANSI B31.3, except that test pressures must be based on the design pressure. Carbon and low alloy steel piping must be pressure tested above their nil ductility transition temperature.

(c) All shells and internal parts of heat exchangers to which Section VIII, Division 1, or Division 2 of the ASME Boiler and Pressure Vessel Code, applies must be pressure tested, inspected, and stamped in accordance therewith.

§ 193.2321 Nondestructive tests.

(a) The following percentages of each day's circumferentially welded pipe joints for hazardous fluid piping, selected at random, must be nondestructively tested over the entire circumference to indicate any defects which could adversely affect the integrity of the weld or pipe:

Weld type	Cryogenic piping	Other	Test method
Butt weld more than 2 inches in nominal size.	100	30	Radiographic or ultrasonic.
Butt welds 2 inches or less in nominal size.	100	30	Radiographic, ultrasonic, liquid penetrant, or magnetic particle.
Fillet and socket welds.	100	30	Liquid penetrant or magnetic particle.

(b) Evaluation of weld tests and repair of defects must be in accordance with the requirements of ANSI B31.3 or API 1104, as applicable.

(c) Where longitudinally or spiral welded pipe is used in transfer systems, 100 percent of the seam weld must be examined by radiographic or ultrasonic inspection.

(d) The butt welds in metal shells of storage tanks with internal design pressure of not more than 15 psig must be radiographically tested in accordance with Section 0.7.6, API 620, Appendix Q, except that for hydraulic load bearing shells with curved surfaces that are subject to cryogenic temperatures, 100 percent of both longitudinal (or meridional) and circumferential or (or latitudinal) welds must be radiographically tested.

(e) The butt welds in metal shells of storage tanks with internal design pressure above 15 psig must be radiographically tested in accordance with Section IX of the ASME Boiler and Pressure Vessel Code, except that for hydraulic load bearing shells with curved surfaces that are subject to cryogenic temperatures, 100 percent of both longitudinal (or meridional) and circumferential (or latitudinal) welds must be radiographically tested.

§ 193.2323 Leak tests.

(a) Each container and piping system must be initially tested to assure that the component will contain the product for which it is designed without leakage.

(b) Shop fabricated containers and all flammable fluid piping must be leak tested to a minimum of the design pressure after installation but before placing it in service.

(c) For a storage tank with vacuum insulation, the inner container, outer shell, and all internal piping must be tested for vacuum leaks in accordance with an appropriate procedure.

§ 193.2325 Testing control systems.

Each control system must be tested before being placed in service to assure that it has been installed properly and will function as required by this part.

§ 193.2327 Storage tank tests.

(a) In addition to other applicable requirements of this subpart, storage tanks for cryogenic fluids with internal design pressures of not more than 15 psig must be tested in accordance with Sections Q8 and Q9 of API 620, Appendix Q, as applicable.

(b) Metal storage tanks for cryogenic fluids with internal design pressures above 15 psig must be tested in accordance with the applicable division of Section VIII of the ASME Boiler and Pressure Vessel Code.

(c) Reference measurements must be made with appropriate precise instruments to assure that the tank is gas tight and lateral and vertical movement of the storage tank does not exceed predetermined design tolerances.

§ 193.2329 Construction records.

For the service life of the component concerned, each operator shall retain appropriate records of the following:

(a) Specifications, procedures, and drawings prepared for compliance with § 193.2305; and

(b) Results of tests, inspections, and the quality assurance program required by this subpart.

Subpart E—Equipment

§ 193.2401 Scope.

This subpart prescribes requirements for the design, fabrication, and installation of vaporization equipment, liquefaction equipment, and control systems.

Vaporization Equipment

§ 193.2403 General.

Vaporizers must comply with the requirements of this subpart and the other applicable requirements of this part.

§ 193.2405 Vaporizer design.

(a) Vaporizers must be designed and fabricated in accordance with applicable provisions of Section VIII, Division 1 of the ASME Boiler and Pressure Vessel Code.

(b) Each vaporizer must be designed for the maximum allowable working pressure at least equal to the maximum discharge pressure of the pump or pressurized container system supplying it, whichever is greater.

§ 193.2407 Operational control.

(a) Vaporizers must be equipped with devices which monitor the inlet pressure of the LNG, the outlet temperature, and the pressure of the vaporized gas, and the inlet pressure of the heating medium fluids.

(b) Manifolded vaporizers must be equipped with:

(1) Two inlet valves in series to prevent LNG from entering an idle vaporizer; and

(2) A means to remove LNG or gas which accumulates between the valves.

§ 193.2409 Shutoff valves.

(a) A shutoff valve must be located on transfer piping supplying LNG to a vaporizer. The shutoff valve must be located at a sufficient distance from the vaporizer to minimize potential for damage from explosion or fire at the vaporizer. If the vaporizer is installed in a building, the shutoff valve must be located outside the building.

(b) A shutoff valve must be located on each outlet of a vaporizer.

(c) For vaporizers designed to use a flammable intermediate fluid, a shutoff valve must be located on the inlet and outlet line of the intermediate fluid piping system where they will be operable during a controllable emergency involving the vaporizer.

§ 193.2411 Relief devices.

The capacity of pressure relief devices required for vaporizers by § 193.2429 is governed by the following:

(a) For heated vaporizers, the capacity must be at least 110 percent of rated natural gas flow capacity without allowing the pressure to rise more than 10 percent above the vaporizer's maximum allowable working pressure.

(b) For ambient vaporizers, the capacity must be at least 150 percent of rated natural gas flow capacity without allowing the pressure to rise more than 10 percent above the vaporizer's maximum allowable working pressure.

§ 193.2413 Combustion air intakes.

(a) Combustion air intakes to vaporizers must be equipped with sensing devices to detect the induction of a flammable vapor.

(b) If a heated vaporizer or vaporizer heater is located in a building, the combustion air intake must be located outside the building.

Liquefaction Equipment

§ 193.2415 General.

Liquefaction equipment must comply with the requirements of this subpart and the other applicable requirements of this part.

§ 193.2417 Control of incoming gas.

A shutoff valve must be located on piping delivering natural gas to each liquefaction system.

§ 193.2419 Backflow.

Each multiple parallel piping system connected to liquefaction equipment must have devices to prevent backflow from causing a hazardous condition.

§ 193.2421 Cold boxes.

(a) Each cold box in a liquefaction system must be equipped with a means of monitoring or detecting, as appropriate, the concentration of natural gas in the insulation space.

(b) If the insulation space in a cold box is designed to operate with a gas rich atmosphere, additional natural gas must be introduced when the concentration of gas falls to 30 percent.

(c) If the insulation space of a cold box is designed to operate with a gas free atmosphere, additional air or inert gas, as appropriate, must be introduced when the concentration of gas is 25 percent of the lower flammable limit.

§ 193.2423 Air in gas.

Where incoming gas to liquefaction equipment contains air, each operator shall provide a means of preventing a flammable mixture from occurring under any operating condition.

Control Systems

§ 193.2427 General.

(a) Control systems must comply with the requirements of this subpart and other applicable requirements of this part.

(b) Each control system must be capable of performing its design function under normal operating conditions.

(c) Control systems must be designed and installed in a manner to permit maintenance, including inspection or testing, in accordance with this part.

(d) Local, remote, and redundant signal lines installed for control systems that can affect the operation of a component that does not fail safe must be routed separately or in separate underground conduits installed in accordance with NFPA-70.

§ 193.2429 Relief devices.

(a) Each component containing a hazardous fluid must be equipped with a system of automatic relief devices which will release the contained fluid at a rate sufficient to prevent pressures from exceeding 110 percent of the maximum allowable working pressure. In establishing relief capacity, each operator shall consider trapping of fluid between valves; the maximum rates of boiloff and expansion of fluid which may occur during normal operation, particularly cooldown; and controllable emergencies.

(b) A component in which internal vacuum conditions can occur must be equipped with a system of relief devices or other control system to prevent development in the component of a vacuum that might create a hazardous condition. Introduction of gas into a component must not create a flammable mixture within the component.

(c) In addition to the control system required by paragraphs (a) and (b) of this section—

(1) Each LNG Storage tank must be equipped with relief devices to assure that design pressure and vacuum relief capacity is available during maintenance of the system; and

(2) A manual means must be provided to relieve pressure and vacuum in an emergency.

(d) Relief devices must be installed in a manner to minimize the possibility that release of fluid could—

(1) Cause an emergency; or

(2) Worsen a controllable emergency.

(e) The means for adjusting the setpoint pressure of all adjustable relief devices must be sealed.

(f) Relief devices which are installed to limit minimum or maximum pressure may not be used to handle boiloff and flash gases during normal operation.

§ 193.2431 Vents.

(a) Hazardous fluids may not be relieved into the atmosphere of a building or other confined space.

(b) Boiloff vents for hazardous fluids may not draw in air during operation.

§ 193.2433 Sensing devices.

(a) Each operator shall determine the appropriate location for and install sensing devices as necessary to—

(1) Monitor the operation of components to detect a malfunction which could cause a hazardous condition if permitted to continue; and

(2) Detect the presence of fire or combustible gas in areas determined in accordance with Section 500-4 of NFPA 70 to have a potential for the presence of flammable fluids.

(b) Buildings in which potentially hazardous quantities of flammable fluids are used or handled must be continuously monitored by gas sensing devices set to activate audible and visual alarms in the building and at the control center when the concentration of the fluid in air is not more than 25 percent of the lower flammable limit.

§ 193.2435 Warning devices.

Each operator shall install warning devices in the control center to warn of hazardous conditions detected by all sensing devices required by this part. Warnings must be given both audibly and visibly and must be designed to gain the attention of personnel. Warnings must indicate the location and nature of the existing or potential hazard.

§ 193.2437 Pump and compressor control.

(a) Each pump and compressor for hazardous fluids must be equipped with—

(1) A control system, operable locally and remotely, to shut down the pump or compressor in a controllable emergency;

(2) A signal light at the pump or compressor and the remote control location which indicates whether the pump or compressor is in operation or off;

(3) Adequate valving to ensure that the pump or compressor can be isolated for maintenance; and

(4) A check valve on each discharge line where pumps or compressors operate in parallel.

(b) Pumps or compressors in a cargo transfer system must have shutdown controls at the loading or unloading area and at the pump or compressor site.

§ 193.2439 Emergency shutdown control systems.

(a) Each transfer system, vaporizer, liquefaction system, and storage system tank must be equipped with an emergency shutdown control system. The control must automatically actuate the shutdown of the component (providing pressure relief as necessary) when any of the following occurs:

(1) Temperatures of the component exceed the limits determined under § 193.2105;

(2) Pressure outside the limits of the maximum and minimum design pressure;

(3) Liquid in receiving vessel reaches the design maximum liquid level;

(4) Gas concentrations in the area of the component exceed 40 percent of the lower flammable limit;

(5) A sudden excessive pressure change or other condition indicating a potentially dangerous condition; and

(6) Presence of fire in area of component.

(b) For cargo transfer systems where all transfer operations are continuously manned and visually supervised by qualified personnel, actuation of the emergency shutdown control system may be manual after devices warn of the events listed in paragraph (a) of this section.

(c) Except for components that operate unattended and are remote from the control center, a reasonable delay may be programmed in emergency shutdown control systems required by this section between warning and automated shutdown to provide for manual response.

(d) Each LNG plant must have a shutdown control system to shut down all operations of the plant safely. The system must be operable at—

(1) The control center; and

(2) In the case of a plant where LNG facilities other than the control center are designed to operate unattended at the site of these facilities.

§ 193.2441 Control center.

Each LNG plant must have a control center from which operations and warning devices are monitored as required by this part. A control center must have the following capabilities and characteristics—

(a) It must be located apart or protected from other LNG facilities so that it is operational during a controllable emergency.

(b) Each remotely actuated control system and each automatic shutdown control system required by this part must be operable from the control center.

(c) Each control center must have personnel in continuous attendance while any of the components under its control are in operation, unless the control is being performed from another control center which has personnel in continuous attendance.

(d) If more than one control center is located at an LNG Plant, each control center must have more than one means of communication with each other center.

(e) Each control center must have a means of communicating a warning of hazardous conditions to other locations within the plant frequented by personnel.

§ 193.2443 Fail-safe control.

Control systems for components must have a fail-safe design. A safe condition must be maintained until personnel take appropriate action either to reactivate the component served or to prevent a hazard from occurring.

§ 193.2445 Sources of power.

(a) Electrical control systems, means of communication, emergency lighting, and firefighting systems must have at least two sources of power which function so that failure of one source does not affect the capability of the other source.

(b) Where auxiliary generators are used as a second source of electrical power—

(1) They must be located apart or protected from components so that they are not unusable during a controllable emergency; and

(2) Fuel supply must be protected from hazards.

Subpart F [Reserved]

Subpart G [Reserved]

Subpart H—Personnel Qualifications and Training

§ 193.2701 Scope.

This subpart prescribes requirements for personnel qualifications and training.

§ 193.2703 Design and fabrication.

For the design and fabrication of components, each operator shall use—

(a) With respect to design, persons who have demonstrated competence by training or experience in the design of comparable components.

(b) With respect to fabrication, persons who have demonstrated competence by training or experience in the fabrication of comparable components.

§ 193.2705 Construction, installation, inspection, and testing.

(a) Supervisors and other personnel utilized for construction, installation, inspection, or testing must have demonstrated their capability to perform satisfactorily the assigned function by appropriate training in the methods and equipment to be used or related experience and accomplishments.

(b) Each operator must periodically determine whether inspectors performing duties under § 193.2307 are satisfactorily performing their assigned function.

Appendix A to Part 193—Incorporation by Reference

I. List of Organizations and Addresses

A. American Concrete Institute (ACI), P.O. Box 19150, Redford Station, Detroit, Michigan 48219.

B. American Gas Association (AGA), 1515 Wilson Boulevard, Arlington, Virginia 22209.

C. American National Standards Institute (ANSI), 1430 Broadway, New York, New York 10018.

D. American Petroleum Institute (API), 2101 L Street, NW., Washington, D.C. 20037.

E. American Society of Mechanical Engineers (ASME), United Engineering Center, 345 East 47th Street, New York, New York 10017.

F. National Fire Protection Association (NFPA), 470 Atlantic Avenue, Boston, Massachusetts 02210.

G. International Conference of Building Officials, 5360 South Workman Hill Road, Whittier, California 90601.

II. Documents Incorporated by Reference

A. American Concrete Institute (ACI)

1. ACI Standard 311-75—Recommended Practice for Concrete Inspection. (1975 edition).

B. American Gas Association (AGA)

1. Evaluation of LNG Vapor Control Methods. (October 1974 edition).

C. American National Standards Institute (ANSI)

1. ANSI A 58.1 Building Code Requirements for Minimum Design Loads in Buildings and Other Structures.

D. American Petroleum Institute (API)

1. API 620-Recommended Rules for Design and Construction of Large, Welded, Low Pressure Storage Tanks (6th edition, July 1977).

2. API 1104 Standard for Welding Pipelines and Related Facilities (14 edition, 1977).

3. API 6D Specifications for Pipeline Valves (17 edition, 1977).

E. American Society of Mechanical Engineers (ASME)

1. ANSI B31.3 Chemical and Plant Petroleum Refinery Piping (1976 edition).

2. ASME Boiler and Pressure Vessel Code, Section 1 Power Boilers (1977 edition).

3. ASME Boiler and Pressure Vessel Code, Section 8 Division 1 (1977 edition).

4. ASME Boiler and Pressure Vessel Code, Section 8 Division 2, Alternative Rules (1977 edition).

5. ASME Boiler and Pressure Vessel Code, Section 9 Welding and Brazing Qualifications (1977 edition).

6. ASME Boiler and Pressure Vessel Code, Section 4 Heating Boilers.

7. ANSI B31.5 Refrigeration Piping (1974 edition).

8. ANSI B31.8 Gas Transmission and Distribution Piping Systems (1975 edition).

F. International Conference of Building Officials

1. UBC, Uniform Building Code (1979 edition).

G. National Fire Protection Association (NFPA)

1. NFPA No. 37 Stationary Combustion Engine and Gas Turbines (1979 edition).

2. NFPA No. 59A Storage and Handling of LNG (1979 edition).

3. NFPA No. 70 National Electric Code (1978 edition).

4. NFPA No. 30 Flammable Liquids.

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