FINAL EXPRESS TERMS
FOR
PROPOSED BUILDING STANDARDS
OF THE
CALIFORNIA STATE LANDS COMMISSION

REGARDING PROPOSED CHANGES TO
THE CALIFORNIA BUILDING CODE
CALIFORNIA CODE OF REGULATIONS, TITLE 24, PART 2
CHAPTER 31F – MARINE OIL TERMINALS

2016 CALIFORNIA BUILDING CODE
TRIENNIAL CODE CYCLE

The State agency shall draft the regulations in plain, straightforward language, avoiding technical terms as much as possible and using a coherent and easily readable style. The agency shall draft the regulation in plain English. A notation shall follow the express terms of each regulation listing the specific statutes authorizing the adoption and listing specific statutes being implemented, interpreted, or made specific. (PART 1 – ADMINISTRATIVE CODE)

LEGEND FOR FINAL EXPRESS TERMS (combination of 45-day and 15-day changes)

1. For 45-day and 15-Day changes, existing California amendments or code language being modified appears in *italics*, with modified language underlined.
2. For 45-day and 15-Day changes, repealed text appears in ~~strikeout~~.

EXPRESS TERMS

[Note: These Express Terms have been assigned item numbers where the first number represents the Division (e.g. "1.1." for Division "1", Item "1").]

DIVISION 1
SECTION 3101F [SLC]
INTRODUCTION

1.1. ***3101F.1 Authority ~~General~~.*** *The Lempert-Keene-Seastrand oil spill prevention and response act of 1990 (act), as amended, authorizes~~d~~ the California State Lands Commission (SLC) to regulate marine terminals, herein referred to as marine oil terminals (MOTs), in order to protect public health, safety and the environment. The authority for this regulation is contained in Sections 8750 through 8760 ~~8755 and 8756~~ of the California Public Resources Code. This act defines "oil" as any kind of petroleum, liquid hydrocarbons, or petroleum products or any fraction or residues thereof, including, but not limited to, crude oil, bunker fuel, gasoline, diesel fuel, aviation fuel, oil sludge, oil refuse, oil mixed with waste, and liquid distillates from unprocessed natural gas. The provisions of this chapter regulate onshore and offshore MOTs ~~marine oil terminals~~ as defined under this act, including marine terminals that transfer liquefied natural gas (LNG).*

The Marine Facilities Division (Division) administers this code on behalf of the SLC.

1.2. ***3101F.2 Purpose.*** *The purpose of this code is to establish minimum engineering, inspection and maintenance criteria for MOTs in order to prevent oil spills and to protect public health, safety and the environment. This code does not specifically~~, in general,~~ address terminal siting or operational requirements. Relevant provisions from existing codes, industry standards, recommended practices, regulations and guidelines have been incorporated directly or through reference, as part of this code.*

Where there are differing requirements between this code and/or references cited herein, the choice of application shall be subject to approval of the ~~Marine Facilities~~ Division ~~(Division) of the SLC~~.

In circumstances where new technologies are proposed, equivalent prevention of oil spills and protection to the public health, safety and the environment must be demonstrated, subject to Division approval.

1.3. ***3101F.4 Overview.***

…

Sections 3109F through 3111F provide requirements for piping/pipelines, mechanical and electrical equipment and electrical systems.

Section 3112F provides requirements specific to marine terminals that transfer LNG.

Generally, English units are typically prescribed herein; however, System International (SI) units are utilized ~~many of the units~~ in Section 3112F and in many of the references ~~are in System International (SI)~~.

1.4. ***3101F.5 Spill prevention.***

Each MOT shall utilize up-to-date Risk and Hazards Analysis results developed per CCPS "Guidelines for Hazard Evaluation Procedures" [1.1] and [1.2], to identify the hazards associated with operations at the MOT, including operator error, the use of the facility by various types of vessels (e.g. multi-use transfer operations), equipment failure, and external events likely to cause an oil spill.

If there are changes made to the built MOT or subsequently any new hazard is identified with significant impact, the updated Risk and Hazards Analysis shall be used.

Assessed magnitude of potential oil spill releases and consequences shall be mitigated by implementing appropriate designs using best achievable technologies, subject to Division approval. The residual risks are addressed by operational and administrative means via 2 CCR 2385 [1.3].

Risk and Hazards Analysis requirements specific to marine terminals that transfer LNG are discussed in Section 3112F.2.

1.5. ***3101F.6 Oil spill exposure classification 5 Risk reduction strategies.*** *Each MOT shall be categorized into one of three oil spill exposure classifications (high, medium or low) as shown in Table 31F-1-1, based on all of the following:*

1. *Exposed total volume of oil (V_T) during transfer.*
2. *Maximum number of oil transfer operations per berthing system (defined in Section 3102F.1.3) per year.*
3. *Maximum vessel size (DWT capacity) that may call at the MOT.*

During a pipeline leak, a quantity of oil is assumed to spill at the maximum cargo flow rate until the ESD is fully effective. The total volume (V_T) of potential exposed oil is equal to the sum of the stored and flowing volumes ($V_S + V_F$) at the MOT, prior to the emergency shutdown (ESD) system(s) stopping the flow of oil. All potential spill scenarios shall be evaluated and the governing scenario clearly identified. The stored volume (V_S) is the non-flowing oil. The flowing volume (V_F) shall be calculated as follows:

$$V_F = Q_C \times \Delta t \times (1/3{,}600) \qquad (1\text{-}1)$$

where

V_F = *Flowing Volume [bbl]*

Q_C = *Maximum Cargo Transfer Rate [bbl/hr]*

Δt = *For MOTs that first transferred oil on or before January 1, 2017, Δt may be taken as (ESD time, 30 or 60 seconds). For MOTs that first transfer oil after January 1, 2017, Δt shall be taken as ((ESD closure time) + (time required to activate ESD)) [seconds].*

If spill Risk reduction strategies, such as (e.g. pipeline segmentation devices, system flexibility and spill containment devices) are adopted, such that the maximum volume of exposed oil during transfer is less than 1,200 barrels, the spill classification of the facility may be lowered. may be used to reduce the size of a potential oil spill. Such strategies may reduce the MOT risk classification as determined from Table 31F-4-1.

This classification does not apply to marine terminals that transfer LNG.

1.6.

TABLE 31F-1-1

MOT OIL SPILL EXPOSURE CLASSIFICATION

SPILL CLASSIFICATION	EXPOSED TOTAL VOLUME OF OIL (V_T) (bbls)	MAXIMUM NUMBER OF TRANSFERS PER BERTHING SYSTEM PER YEAR	MAXIMUM VESSEL SIZE (DWT×1,000)
High	≥ 1200	N.A.	N.A.
Moderate	< 1200	≥ 90	≥ 30
Low	< 1200	< 90	< 30

1.7. ***3101F.7 Management of Change.*** *Whenever physical changes are made to the built MOT that significantly impact operations, a Management of Change (MOC) process shall be followed per Section 6.6 of API Standard 2610 [1.4].*

1.8. *3101F.86 Review requirements.*

1.9. *3101F.86.1 Quality assurance.* *All audits, inspections, engineering analyses or designs shall be reviewed by a professional having similar or higher qualifications as the person who performed the work, to ensure quality assurance. This review may be performed in-house, and shall include a concluding statement of compliance with this code.*

Peer review is required for nonlinear dynamic structural analyses and alternative lateral force procedures not prescribed herein. The peer review may be from an independent internal or external source. The peer reviewer shall be a California registered civil or structural engineer.

1.10. *3101F.8.2 Peer review.* *The Division may require peer review of advanced engineering analyses and designs, including, but not limited to, nonlinear dynamic structural analyses, alternative lateral force procedures, complex geotechnical evaluations, subsea pipeline analyses and designs, and fatigue analyses. Peer review shall be performed by an external independent source to maintain the integrity of the process.*

The peer reviewer(s) and their affiliated organization shall have no other involvement in the project, except in a review capacity. The peer reviewer(s) shall be a California registered engineer(s) familiar with regulations governing the work and have technical expertise in the subject matter to a degree of at least that needed for the original work. The peer reviewer(s)' credentials shall be presented to the Division for approval prior to commencement of the review.

Upon completion of the review process, the peer reviewer(s) shall submit a written report directly to the Division that covers all aspects of the review process, including, but not limited to:

1. *Scope, extent and limitations of the review.*
2. *Status of the documents reviewed at each stage (i.e. revision number and date).*
3. *Findings.*
4. *Recommended corrective actions and resolutions, if necessary.*
5. *Conclusions.*
6. *Certification by the peer reviewer(s), including whether or not the final reviewed work meets the requirements of this code.*
7. *Formal documentation of important peer review correspondence, including requests for information and written responses.*

The owner and operator shall cooperate in the review process, but shall not influence the peer review. If the original work requires modification after completion of the peer review, the final analyses and designs shall be submitted to the Division.

1.11. *3101F.8.36.2 Division review. …*

1.12. *3101F.97 Alternatives. …*

1.13. ***3101F.10 References.***

[1.1] Center for Chemical Process Safety (CCPS), 2008, "Guidelines for Hazard Evaluation Procedures", 3rd ed., New York.

[1.2] California Code of Regulations (CCR), Title 14, Division 1, Chapter 3, Oil Spill Contingency Plans (14 CCR 815.01 through 818.03), Section 817.02(c)(1) – Risk and Hazard Analysis

[1.3] California Code of Regulations (CCR), Title 2, Division 3, Chapter 1, Article 5 – Marine Terminals Inspection and Monitoring (2 CCR 2300 et seq.)

[1.4] American Petroleum Institute (API), 2005, API Standard 2610 (R2010), "Design, Construction, Operation, Maintenance, and Inspection of Terminal and Tank Facilities," 2nd ed., Washington, D.C.

Authority: Sections 8750 through 8760 ~~8755 and 8757~~, Public Resources Code.

Reference: Sections 8750, 8751, 8755 and 8757, Public Resources Code. Section 8670.28(a)(7), Government Code.

Notation
Authority: Sections 8750 through 8760, Public Resources Code.
References: Sections 8750, 8751, 8755 and 8757, Public Resources Code. Section 8670.28(a)(7), Government Code.

DIVISION 2
SECTION 3102F
AUDIT AND INSPECTION

2.1. ***3102F.1.2 Audit and inspections~~s~~ types.*** *The audit and inspections described in this Chapter (31F)~~ and 2 CCR 2320 (a) and (b) [2.1]~~ are:*

1. *Annual compliance inspection*
2. *Audits*
3. *Post-event inspection*

Each has a distinct purpose and is conducted either at a defined interval (see Table 31F-2-1 and Section 3102F.3.3~~.2~~), for a significant change in operations, or as a result of a significant, potentially damage-causing event~~ or a significant change in operations~~. In the time between audits and inspections, operators are expected to conduct periodic walk-down examinations of the MOT to detect potentially unsafe conditions.

2.2. ***3102F.1.3 Berthing systems.*** *For the purpose of assigning structural ratings and documenting the condition of mechanical and electrical systems, an MOT shall be divided into independent "berthing systems." A berthing system consists of the wharf and supporting structure, mechanical and electrical components that serve the berth and pipeline systems~~ as defined in Title 2 CCR §2560 and 2561 (n)~~.*

…

2.3. ***3102F.1.4 Records.*** *All MOTs shall have records reflecting current, "as-built" conditions for all berthing systems. …*

…

2.4. ***3102F.1.5 Baseline assessment ~~inspection~~.*** *If "as-built" or subsequent modification drawings are not available, incomplete or inaccurate, a baseline inspection is required to gather data in sufficient detail for adequate evaluation ~~evaluaton~~.*

…

2.5. ***3102F.2 Annual compliance inspection.*** *The Division may carry out annual inspections to determine the compliance status of the MOT with this code, based on the terminal's audit and inspection findings and action plan implementation (see Section 3102F.3.9). ~~required by 2 CCR 2320 (a)(1) [2.1], may include an engineering examination of the topside and underside areas of the dock, including the splash zone. The Division shall perform the inspection, with cooperation from the owner/operator. Observations will be recorded and a report of violations and deficiencies shall be provided to the operator.~~*

These inspections may include a visual and tactile assessment of structural, mechanical and electrical systems of the topside and underside areas of the dock, including the splash zone. Subject to operating procedures, a boat shall be provided to facilitate the inspection of the dock undersides and piles down to the splash zone. ~~If a boat is not available or the under dock inspection cannot be performed by the~~

~~*Division during the annual inspection, the MOT operator shall carry out or cause to be carried out, such an inspection. The operator will then provide the Division with a report detailing the examination results including photographs, videos and sketches as necessary to accurately depict the state of the underside of the dock.*~~

2.6. ***3102F.3.3.2 Subsequent audits.*** *A subsequent audit ~~report~~ of each terminal shall be completed ~~at a maximum interval of 4 years, and~~ concurrently with the ~~includes documentation of~~ inspections (see Section 3102F.3.5). ~~This interval may be reduced, based on the recommendation of the audit team leader, and with the approval of the Division, depending on the extent and rate of deterioration or other factors.~~ The audit team leader shall recommend either: (1) a default subsequent audit interval of 4 years, or (2) an alternate interval, based on assessments of the structural, mechanical and electrical systems, and consideration of:*

1. *The extent of the latest deterioration and/or disrepair,*
2. *The rate of future anticipated deterioration and/or disrepair,*
3. *The underwater inspection guidance provided in Table 31F-2-1, and*
4. *Other specified factors.*

Based on independent assessment of these factors, the Division may accept the audit team leader's recommendation or require a different subsequent audit interval.

~~*The maximum interval for above water inspections shall be 4 years. The maximum interval for underwater inspections is dependent upon the condition of the facility, the construction material type and/or the environment at the mudline, as shown in Table 31F-2-1.*~~

If there are no changes in the defined purpose (see Section 3102F.3.6.1) of the berthing system(s), relevant prior analyses ~~then analyses from previous audits~~ may be referenced. However, if there is a significant change in the operations or condition of ~~a~~ berthing system(s), ~~or when deterioration or damage must be considered,~~ a new analysis may be required.

The Division may require an audit, inspections or supplemental evaluations to justify changes in the use of the berthing system(s).

2.7. ***3102F.3.4.7 Corrosion specialist.*** *The corrosion specialist shall be a chemical engineer, corrosion engineer, chemist or other professional with expertise in the types and causes of corrosion, and available means to prevent, monitor and mitigate associated damage. The specialist shall perform the corrosion assessment (Section 3102F.3.6.5) and may be directly involved in corrosion inspection (Section 3102F.3.5.5).*

2.8. ***3102F.3.4.9~~7~~ Division~~al~~ representation.*** *The Division representative(s) may participate in any audit or inspection as observer(s) ~~and may provide guidance~~. The Division shall be notified in advance of audit-related inspections.*

2.9. ***3102F.3.5.1 Structural inspections.***

2.10. ***3102F.3.5.1.1 Above water structural inspection.*** *The above water inspection shall include all accessible components ~~above +3 ft MLLW. Accessible components shall be defined as those components~~ above and below deck that are reachable without the need for excavation or extensive removal of materials that may impair visual inspection. The above water inspection shall include, but not be limited to, the following:*

…

2.11. ***3102F.3.5.1.2 Underwater structural inspection.*** *The underwater inspection shall include all ~~accessible~~ components below deck ~~from +3 ft MLLW~~ to the mudline, including the slope and slope protection, in areas immediately surrounding the MOT. The water depth at the berth(s) shall be evaluated, verifying the maximum or loaded draft specified in the MOT's Operations Manual (2 CCR 2385 ~~(d)~~) [2.1].*

The underwater structural inspection shall include the Level I, II and III inspection efforts, as shown in Tables 31F-2-2 and 31F-2-3. The underwater inspection levels of effort are described below, per [2.2]:

Level I…

Level II… For piles, a 12-inch high band shall ~~should~~ be cleaned at designated locations, generally near the low waterline, at the mudline ~~mud-line~~, and midway between the low waterline and the mudline. … The Level II effort is intended to detect and identify damaged and deteriorated areas that may be hidden by surface biofouling. The thoroughness of marine growth removal should be governed by what is necessary to discern the condition of the underlying structural material. Removal of all biofouling staining is generally not required. ~~intended to detect and identify damaged and deteriorated areas that may be hidden by surface biofouling. The thoroughness of marine growth removal should be governed by what is necessary to discern the condition of the underlying structural material. Removal of all biofouling staining is generally not required.~~

Level III…

2.12.

TABLE 31F-2-3

SCOPE OF UNDERWATER INSPECTIONS [2.2]

		SAMPLE SIZE AND METHODOLOGY[1]							
		Steel		***Concrete***		***Timber***		***Composite***	***Slope Protection, Channel Bottom or Mudline-Scour***
LEVEL		***Piles***	***Bulkheads/ Retaining Walls***	***Piles***	***Bulkheads/ Retaining Walls***	***Piles***	***Bulkheads/ Retaining Walls***	***Piles***	
I	***Sample Size:*** ***Method:***	*100%* *Visual/Tactile*	*100%* *Visual/Tactile*	*100%* *Visual/Tactile*	*100%* *Visual/Tactile*	*100%* *Visual/Tactile*	*100%* *Visual/Tactile*	*100%* *Visual/Tactile*	*100%* *Visual/Tactile*
II	***Sample Size:*** ***Method:***	*10%* *Visual: Removal of marine growth in 3 bands*	*Every 100 LF* *Visual: Removal of marine growth in 1 SF areas*	*10%* *Visual: Removal of marine growth in 3 bands*	*Every 100 LF* *Visual: Removal of marine growth in 1 SF areas*	*10%* *Visual: Removal of marine growth on 3 bands Measurement: Remaining diameter*	*Every 50 LF* *Visual: Removal of marine growth in 1 SF areas*	*10%* *Visual: Removal of marine growth in 3 bands*	~~*0%*~~ *As Necessary*
III	***Sample Size:*** ***Method:***	*5%* *Remaining thickness measurement; electrical potential measurement; corrosion profiling as necessary*	*Every 200 LF* *Remaining thickness measurement; electrical potential measurement; corrosion profiling as necessary*	*0%* *N/A*	*0%* *N/A*	*5%* *Internal marine borer infestation evaluation*	*Every 100 LF* *Internal marine borer infestation evaluation*	*0%*	~~*0%*~~ *Sonar imaging as necessary*

1. The minimum inspection sampling size for small structures shall include at least two components.

LF = Linear Feet; SF = Square Feet; N/A = Not Applicable

2.12a. *3102F.3.5.2~~3~~ Special inspection considerations.*

2.12b. *3102F.3.5.2~~3~~.1 Coated components. …*

2.12c. *3102F.3.5.2~~3~~.2 Encased components. …*

2.12d. *3102F.3.5.2~~3~~.3 Wrapped components. …*

2.13. *3102F.3.5.3~~4~~ Mechanical and electrical inspections. …*

…

Utility, auxiliary and fire protection piping shall have external visual inspections, similar to that defined in Section 10.1 of API RP 574 [2.3] (N/E).

2.14. ***3102F.3.5.4 Corrosion inspection.***

During each audit, a comprehensive corrosion inspection shall be performed by a qualified engineer or technician. This inspection shall include all steel and metallic components, and any installed cathodic protection system (CPS). CPS inspection during the audit is not intended to substitute for required testing and maintenance performed on a more frequent schedule per Section 3111F.10. All inspection results shall be documented, and shall be used in the corrosion assessment (Section 3102F.3.6.5).

Submerged wharf structures and associated cathodic protection equipment (if installed) shall be inspected per [2.2]. Above water structures, ancillary equipment, supports, and hardware shall be visually inspected. Corrosion inspection of utility, auxiliary and fire pipelines shall be done per Section 3102F.3.5.3.

For oil pipelines in an API 570 [2.4] inspection program, a corrosion inspection is not required as part of the audit; however, the latest inspection results, calculations, and conclusions shall be reviewed, and any significant results shall be included in the corrosion assessment.

2.15. ***3102F.3.6.5 Corrosion assessment (N/E).*** *A comprehensive assessment shall be performed by the corrosion specialist (Section 3102F.3.4.7), to determine the existing and potential corrosion using "as-built" drawings and specifications. This assessment shall comprise all steel and metallic components, including the structure, pipelines, supports and other MOT ancillary equipment. This assessment shall also include prestressed and reinforced concrete structures.*

If cathodic protection is installed to protect wharf structures and/or pipelines, the following records shall be evaluated for each system:

1. CPS equipment condition and maintenance

2. Impressed current readings (as applicable)

3. Potential survey results

2.16. ***3102F.3.7 Follow-up actions.*** *Follow-up actions per ~~as described in~~ Table 31F-2-6 shall be prescribed by the audit team. Multiple follow-up actions may be assigned; however, guidance shall be provided as to the order in which the follow-up actions should be carried out.*

If an assessment rating of "1", "2" or "3" (Table 31F-2-4) or a RAP of "P1" or "P2" (Table 31F-2-5) or "Emergency Action" using Table 31F-2-6, is assigned to a structure, berthing system or critical component, the Division shall be notified immediately. The Executive Summary Table ES-2 (see Example Table 31F-2-8) shall include implementation schedules for all follow-up and remedial actions. Follow-up and remedial actions and implementation schedules are subject to Division approval. ~~Executive Summary Tables shall be maintained and updated by the MOT, and shall be submitted in the audit and/or upon Division request.~~

For action plan implementation between audits, see Section 3102F.3.9.

2.17. ***3102F.3.9 Action plan implementation between audits ~~report~~.*** *The operator is responsible for correction of deficiencies between audits. Prior to implementation, projects shall be submitted for Division review in accordance with Section 3101F.8.3. During project implementation, the Division shall be informed of any significant changes. After project completion, "as-built" documentation, including drawings, calculations and analyses, shall be submitted to the Division.* ~~*After implementation of remedial measures, a report shall be submitted to the Division and shall include:*~~

~~*1. A description of each action taken*~~

~~*2. Updated Executive Summary Tables*~~

~~*3. Supporting documentation with calculations and/or relevant data*~~

Executive Summary Tables shall be updated by the operator and submitted to the Division at least annually.

[Note: Double underline denotes proposed language which will be underlined in code.]

2.18. ***3102F.5 References.***

[2.1] California Code of Regulations (CCR), Title 2, Division 3, Chapter 1, Article 5 – Marine Terminals Inspection and Monitoring (2 CCR 2300 et seq.) ~~*Article 5, Marine Terminals Inspection and Monitoring, Sections 2315, 2320, 2325 and 2385 (short form example: 2 CCR § 2315 (Title 2 of California Code of Regulations, Section 2315).*~~

[2.2] Childs, K.M., editor, 2001, "Underwater Investigations - Standard Practice Manual," American Society of Civil Engineers, Reston, VA.

[2.3] American Petroleum Institute (API), 2009, API Recommended Practice 574 (API RP 574), "Inspection Practices for Piping System Components," 3rd ed., Washington, D.C.

[2.4] American Petroleum Institute (API), 2009, API 570, "Piping Inspection Code: In-service Inspection, Rating, Repair, and Alteration of Piping Systems," 3rd ed., Washington, D.C.

Authority: Sections 8750 through 8760 ~~*8755 and 8757*~~*, Public Resources Code.*

Reference: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

Notation
Authority: Sections 8750 through 8760, Public Resources Code.
References: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

DIVISION 3
SECTION 3103F
STRUCTURAL LOADING CRITERIA

3.1 ***3103F.4.1 General.*** *… The required seismic analysis procedures (Tables 31F-4-1 ~~31F-4-2~~ and 31F-4-2 ~~31F-4-3~~) are dependent on the spill ~~risk~~ classification obtained from Table 31F-1-1 ~~31F-4-1~~.*

3.2 ***3103F.4.2 Design earthquake motion parameters.*** *The earthquake ground motion parameters of peak ground acceleration, spectral acceleration and earthquake magnitude are modified for site amplification and near fault directivity effects. The resulting values are the D~~d~~esign P~~p~~eak G~~g~~round A~~a~~cceleration (DPGA), D~~d~~esign S~~s~~pectral A~~a~~cceleration (DSA) and D~~d~~esign E~~e~~arthquake M~~m~~agnitude (DEM).*

For Site Classes A through E (Section 3103F.4.2.1), ~~The~~ peak ground and design spectral accelerations may be obtained from ~~evaluated using~~:

1. *U.S. Geological Survey (USGS) published data ~~or California Geological Survey [CGS, formerly the California Division of Mines and Geology (CDMG)] maps~~ as discussed in Section 3103F.4.2.2, or*
2. *A site-specific probabilistic seismic hazard analysis (PSHA) as discussed in Section 3103F.4.2.3.*
3. ~~*For the Ports of Los Angeles, Long Beach and Port Hueneme, PSHA results are provided in Section 3103F.4.2.3.*~~

Site-specific PSHA is required for Site Class F.

…

The appropriate probability levels associated with DPGA and DSA for different seismic performance levels are provided in Table 31F-4-1 ~~31F-4-2~~. …

…This parameter is required when acceleration time histories (Section 3103F.4.2.10) are addressed or if liquefaction potential (Section 3106F.4 ~~3106F.3~~) is being evaluated.

[Note: Double underline denotes proposed language, which will be underlined in code.]

3.3. ***3103F.4.2.1 Site classes.*** *The following S~~s~~ite C~~c~~lasses, defined in Section 3106F.2.1, shall be used in developing values of DSA and DPGA:*

A, B, C, D, E and F ~~S_A, S_B, S_C, S_D, S_E, and S_F.~~

For Site Class F ~~S_F~~, a site-specific response analysis is required per Section 3103F.4.2.5.

3.4. ***3103F.4.2.2 Earthquake motions from USGS maps.*** *Earthquake ground motion parameters can be obtained directly from the US Seismic Design Maps tool available at the USGS website (http://earthquake.usgs.gov/designmaps/us/application.php) for the site condition(s) appropriate for the MOT site and the selected probability of exceedance. For this purpose, select the "2013 ASCE 41" as the design code reference document (based on 2008 USGS hazard data available), "Custom" under the Earthquake Hazard Level option, required Probability of Exceedance (in 50 years), and appropriate Site Soil Classification(s) for the MOT site. The USGS tool directly provides the peak ground and spectral accelerations for the selected hazard level and site condition(s).*

The alternative method of obtaining earthquake ground motion parameters, from the most current USGS data for selected hazard level and site condition(s), is permitted. If needed, the data for appropriate probability of exceedance may be obtained using the procedure described in Chapter 1 of FEMA 356 [3.1], and corrected for the MOT site as discussed in Section 3103F.4.2.4 or Section 3103F.4.2.5.

Earthquake ground motion parameters can be obtained from the Maps 29-32 in the National Earthquake Hazard Reduction Program (NEHRP) design map set discussed in subsection 1.6.1 of [3.1], or the USGS website: (http://earthquake.usgs.gov/research/hazmaps/). These are available as peak ground acceleration and spectral acceleration values at 5 percent damping for 10 and 2 percent probability of exceedance in 50 years, which correspond to Average Return Periods (ARPs) of 475 and 2,475 years, respectively. The spectral acceleration values are available for 0.2, and 1.0 second spectral periods. In obtaining peak ground acceleration and spectral acceleration values from the USGS web site, the site location can be specified in terms of site longitude and latitude or the zip code when appropriate. The resulting values of peak ground acceleration and spectral acceleration correspond to surface motions for Site Classification approximately corresponding to the boundary of Site Class S_B and S_C.

Once peak ground acceleration and spectral acceleration values are obtained for 10 and 2 percent probability of exceedence in 50 years, the corresponding values for other probability levels may be obtained. A procedure is presented in subsection 1.6 of Chapter 1 of [3.1].

3.5. ***3103F.4.2.3 Earthquake motions from site-specific probabilistic seismic hazard analyses.*** *Site-specific Probabilistic Seismic Hazard Analysis (PSHA) shall use appropriate seismic sources and their characterization, attenuation relationships, probability of exceedance, and site soil conditions. Site-specific PSHA shall be conducted by a qualified California registered civil engineer with a California authorization as a geotechnical engineer per Section 3102F.3.4.8.*

If site-specific PSHA is used for Site Classes A, B, C, D or E, results from the site-specific PSHA shall be compared with those from the USGS published data as described in Section 3103F.4.2.2. If the two sets of values differ significantly, a justification for using the characterization chosen shall be provided. If DPGA and DSA from site-specific PSHA are less than 80 percent of the values from USGS data, a peer review may be required.

Peak ground acceleration and spectral acceleration values can be obtained using site-specific probabilistic seismic hazard analysis (PSHA). In this approach, the seismic sources and their characterization used in the analysis shall be based on the published data from the California Geological Survey, which can be obtained online at the following website: (http://www.conservation.ca.gov/CGS/Pages/Index.aspx) [3.2].

Appropriate attenuation relationships shall be used to obtain values of peak ground acceleration and spectral acceleration at the ground surface for site conditions corresponding to the boundary of Site Class S_B and S_C, regardless of the actual subsurface conditions at the site. These results shall be compared to those based on the FEMA/USGS maps discussed in subsection 3103F.4.2.2. If the two sets of values are significantly different, a justification for using the characterization chosen shall be provided.

Alternatively, peak ground acceleration and spectral accelerations at the ground surface for the subsurface conditions that actually exist at the site may be directly obtained by using appropriate attenuation relationships in a site-specific PSHA. This approach is not permissible for Site Classes S_E and S_F.

~~*For site-specific PSHA, peak ground acceleration and spectral acceleration values corresponding to the seismic performance level (See Table 31F-4-2) shall be obtained.*~~

~~*For peak ground acceleration, PSHA may be conducted using the "magnitude weighting" procedure in Idriss [3.3]. The actual magnitude weighting values should follow the Southern California Earthquake Center (SCEC) procedures [3.4]. This magnitude weighting procedure incorporates the effects of duration corresponding to various magnitude events in the PSHA results. The resulting peak ground acceleration shall be used only for liquefaction assessment (see subsection 3106F.4).*~~

~~*PSHA have been developed for the Port of Los Angeles and Long Beach [3.5, 3.6] and provide site-specific information for seismic analyses. Table 31F-3-3 provides response spectra, for a 475 year return period earthquake and 5 percent critical damping. Figure 31F-3-1 provides the corresponding spectra for the two ports. Additionally, these references provide spectra for return periods from 72 to 2,500 years.*~~

~~*For the port of Port Hueneme, a PSHA was performed by Lawrence Livermore National Laboratory [3.7] and the results are shown in Table 31F-3-4 and Figure 31F-3-2. These results are provided only for site classification "S_C" and five percent critical damping. To obtain appropriate values for piles and/or the mudline, the simplified procedures of subsection 3103F.4.2.4 may be used.*~~

3.6. Remove entirely: ~~***FIGURE 31F-3-1 DESIGN ACCELERATION RESPONSE SPECTRA FOR THE PORTS OF LOS ANGELES AND LONG BEACH, 475 YEAR RETURN PERIOD (5% Critical Damping)***~~

3.7. Remove entirely: ~~***FIGURE 31F-3-2 RESPONSE SPECTRA FOR PORT HUENEME, 475 YEAR RETURN PERIOD (5% Critical Damping)***~~

3.8. ***3103F.4.2.4 Simplified evaluation of site amplification effects.*** *When the MOT s~~S~~ite c~~C~~lass is different from the Site Classes B to C ~~S_B - S_C~~ boundary, site amplification effects shall be incorporated in peak ground accelerations and spectral accelerations. This may be accomplished using a simplified method or a site-specific evaluation (Section 3103F.4.2.5).*

For a given site class, the following procedure from Chapter 1 of FEMA 356 [3.1] presents a simplified method that may be used to incorporate the site amplification effects for peak ground acceleration and spectral acceleration computed for the Site Classes B ~~S_B~~ and C ~~S_C~~ boundary.

1. *Calculate the spectral acceleration values at 0.20 and 1.0 second period:*

$$S_{XS} = F_a S_S \quad (3\text{-}1)$$

$$S_{X1} = F_v S_1 \quad (3\text{-}2)$$

where:

F_a = *site coefficient obtained from Table 31F-3-3 ~~31F-3-5~~*

F_v = *site coefficient obtained from Table 31F-3-4 ~~31F-3-6~~*

S_S = *short period (usually at 0.20 seconds) spectral acceleration value (for the boundary of Site Classes B ~~S_B~~ and C ~~S_C~~) obtained using Section 3103F.4.2.2, or at the period corresponding to the peak in spectral acceleration values when obtained from Section 3103F.4.2.3*

S_1 = spectral acceleration value (for the boundary of Site Classes B ~~S_B~~ and C ~~S_C~~) at 1.0 second period

S_{XS} = spectral acceleration value obtained using the short period S_S and factored by Table 31F-3-3 ~~31F-3-5~~ for the s~~S~~ite c~~C~~lass under consideration.

S_{X1} = spectral acceleration value obtained using the 1.0 second period S_1 and factored by Table 31F-3-4 ~~31F-3-6~~ for the s~~S~~ite c~~C~~lass under consideration.

2. …

where:

PGA_X = peak ground acceleration corresponding to the s~~S~~ite c~~C~~lass under consideration.

…

3. PGA_X, S_{XS}, and S_{X1} constitute three spectral acceleration values for the s~~S~~ite c~~C~~lass under consideration…

4. The final response spectra, without consideration for near-fault directivity effects, values of S_a for the s~~S~~ite c~~C~~lass …

…

The resulting PGA_X is the DPGA. However, the S_a ~~(except for the ports of Los Angeles, Long Beach and Port Hueneme)~~ shall be modified for near-fault directivity effects, per Section 3103F.4.2.6 ~~3103F.4.2. 6~~ to obtain the final DSAs.

3.9. Remove entirely: ~~***TABLE 31F-3-3 DESIGN ACCELERATION RESPONSE SPECTRA FOR THE PORTS OF LOS ANGELES AND LONG BEACH, 475 YEAR RETURN PERIOD (5% Critical Damping)***~~

3.10. Remove entirely: ~~***TABLE 31F-3-4 RESPONSE SPECTRA FOR PORT HUENEME, 475 YEAR RETURN PERIOD (5% Critical Damping)***~~

3.11. Modify existing Table 31F-3-5 as following:

(1) ***TABLE 31F-3-3*** ~~***31F-3-5***~~ ***VALUES OF F_a*** and

(2) Re-label the Site Classes (S_A, S_B, S_C, S_D, S_E and S_F) to (A, B, C, D, E and F), respectively.

(3) Correct footnote as follows: * *Site-specific dynamic site response analysis shall be ~~he~~ performed.*

3.12. Modify existing Table 31F-3-6 as following:

(1) ***TABLE 31F-3-4*** ~~***31F-3-6***~~ ***VALUES OF F_V*** and

(2) Re-label the Site Classes (S_A, S_B, S_C, S_D, S_E and S_F) to (A, B, C, D, E and F), respectively.

(3) Correct footnote as follows: * *Site-specific dynamic site response analysis shall be ~~he~~ performed.*

3.13. ***3103F.4.2.5 Site-specific evaluation of amplification effects.*** *As an alternative to the procedure presented in Section 3103F.4.2.4, a site-specific response analysis may be performed. For Site Class F ~~S_F~~, a site-specific response analysis is required. …*

In general, an equivalent linear analysis using, for example, SHAKE91 [3.2]~~[3.8]~~ is acceptable when the strength and stiffness of soils are unlikely to change significantly during the seismic shaking,…

…

~~For the port areas of Los Angeles, Long Beach and Port Hueneme, the resulting response spectra shall not fall below values obtained in Section 3103F.4.2.3.~~

The peak ground accelerations obtained from this site-specific evaluation are DPGAs and the spectral accelerations are DSAs as long as the near-fault directivity effects addressed in Section 3103F.4.2.6 ~~3103F.4.2. 6~~ are appropriately incorporated into the time histories (Section 3103F.4.2.10).

[Note: Double underline denotes proposed language, which will be underlined in code. In this case, the entire sentence should have a single underline in the code.]

3.14. ***3103F.4.2.6 Directivity effects.*** *When the site is 15 km (9.3 miles) or closer to a seismic source that can significantly affect the site, near-fault directivity effects shall be reflected in the spectral acceleration values and in the deterministic spectral acceleration values of Section 3103F.4.2.7 ~~3103F.4.2. 7~~. ~~However, Tables 31F-3-3 and 31F-3-4 for the port areas of Los Angeles, Long Beach and Port Hueneme already have these effects included.~~*

Two methods are available for incorporating directivity effects:~~.~~

1. *Directivity effects may be reflected in the spectral acceleration values in a deterministic manner by using well established procedures such as that described in~~, for example, the equation on pg. 213 (and Tables 6 and 7) of~~ Somerville, et al. [3.3]~~[3.9]~~. …*
2. *…*

   …

3.15 ***3103F.4.2.7 Deterministic earthquake motions.*** *…*

… In this case, the median values of peak ground acceleration and spectral acceleration values shall be 2/3 ~~213~~ (see S~~ubs~~ection 1.6 of FEMA 356 [3.1]) of the values shown on the USGS maps.

3.16. ***3103F.4.2.8 Design E~~e~~arthquake M~~m~~agnitude.*** *The D~~d~~esign E~~e~~arthquake M~~m~~agnitude used in developing site-specific acceleration time histories (Section 3103F.4.2.10) or liquefaction assessment (Section 3106F.4 ~~3106F.3~~) is obtained using either of the following two methods:~~.~~*

1. *…*
2. *…*

3.17. ***3103F.4.2.9 Design S~~s~~pectral A~~a~~cceleration for various damping values.*** *Design S~~s~~pectral A~~a~~cceleration (DSA) values at damping other than 5 percent shall be obtained by using a procedure given in Chapter 1 of FEMA 356 [3.1], and is denoted as DSA_d….*

…

Values of B_S and B_1 are obtained from Table 31F-3-5 ~~31F-3-7~~.

…

3.18. ***TABLE 31F-3-5 ~~31F-3-7 [3.1]~~ VALUES OF B_S AND B_1 [3.1]***

3.19. ***3103F.5.1 General.*** *…*

The vessel's moorings shall be strong enough to hold during all expected conditions of surge, current and weather and long enough to allow adjustment for changes in draft, drift, and tide (2 CCR 2340 ~~(c) (1)~~) [3.4]~~[3.10]~~.

3.20. ***3103F.5.2.1.2 Survival condition.*** *…*

… If the wind rises above these levels, the vessel must depart the berth; it shall be able to depart within 30 minutes (see 2 CCR 2340 ~~(c) (28)~~) [3.4]~~[3.10]~~.

… If other duration wind data is available, it shall be adjusted to a 30-second duration, in accordance with Equation (3-12)~~(3.12)~~. The 25-year return period shall be used to establish the design wind speed for each direction. In order to simplify the analysis for barges (or other small vessels), they may be considered to be solid free-standing walls (Chapter 29 ~~6~~ of ASCE/SEI 7 [3.5]~~[3.11]~~). …

3.21. ***3103F.5.2.2 Wind speed corrections.*** *…*

…

c_t = *conversion factor from Figure 31F-3-1 ~~31F-3-3~~*

If wind data is available over land only, the following equation shall be used to convert the wind speed from over-land to over-water conditions [3.6]~~[3.10]~~:

…

3.22. ***FIGURE 31F-3-1 ~~31F-3-3~~ WIND SPEED CONVERSION FACTOR [3.6]~~[3.12]~~***

3.23. ***3103F.5.2.3 Static wind loads on vessels.*** *The OCIMF MEG3 [3.7] ~~"Mooring Equipment Guidelines (MEG3)" [3.13] or the "British Standard Code of Practice for Maritime Structures" [3.14]~~ shall be used to determine the wind loads for all tank vessels.*

Alternatively, wind loads for any type of vessel may be calculated using the guidelines in Ferritto et al. [3.8]~~, 1999 [3.15]~~.

3.24. ***3103F.5.3.1 Design current velocity.*** *…*

Local current velocities may be obtained from NOAA [3.9]~~[3.16]~~ or other sources, but must be supplemented by site-specific data, if the current velocity is higher than 1.5 knots.

…

3.25. ***3103F.5.3.2 Current velocity adjustment factors.*** *…*

…

If the velocity profile is not known, the velocity at a known water depth shall ~~should~~ be adjusted by the factors provided in Figure 31-F-3-2 ~~31F-3-4~~ to obtain the equivalent average velocity over the draft of the vessel.

3.26. ***FIGURE 31F-3-2 ~~31F-3-4~~* CURRENT VELOCITY CORRECTION FACTOR (p. 23~~, OCIMF, 1997~~ *[3.7]~~[3.13]~~*)**

3.27. ***3103F.5.3.3 Static current loads.*** *The OCIMF MEG3 [3.7]~~[3.13], the British Standard [3.14]~~ or the UFC 4-159-03 [3.10]~~[3.17]~~ procedures shall be used to determine current loads for moored tank vessels.*

3.28. ***3103F.5.4 Wave loads.*** *When the significant wave period, T_s ~~Ts~~, is greater than 4 seconds (s~~S~~ee Section 3105F.3.1), …*

… The Froude-Krylov method discussed in Chakrabarti's Chapter 7 [3.11]~~[3.18]~~ may be used to calculate the wave excitation forces, …

3.29. ***3103F.5.5 Passing vessels.*** *…*

… Either method of Kriebel [3.12] ~~Krieble~~ ~~[3.19]~~ or Wang [3.13]~~[3.20]~~ may be used to determine forces on a moored vessel. Kriebel's recent wave tank study improves on an earlier work of Seelig [3.14]~~[3.21]~~.

3.30. ***3103F.5.7 Tsunamis.*** *…*

…

Tsunamis can be generated either by a distant or near source. A tsunami generated by a distant source (far field event) may allow operators to have an adequate warning for mitigating the risk by allowing the vessels to depart the MOT and go into deep water. For near-field events, with sources less than 500 miles away, the vessel may not have adequate time to depart. Each MOT shall have a "tsunami plan" describing what actions will be performed, in the event of a distant tsunami.

Recent tsunami studies have been completed for both Southern and Northern California. For the Ports of Los Angeles and Long Beach, one of these ~~those~~ recent studies focused on near field tsunamis with predicted return periods of 5,000 to 10,000 years [3.15]~~[3.22]~~. …

The run-up value for Port Hueneme was obtained from an earlier study by Synolakis et al. [3.16]~~[3.23]~~.

Run up-values: Port of Los Angeles and Long Beach = 8 ft.

Port Hueneme = 11 ft.

… These results are deterministic and are based on the most severe seismic sources that could reasonably impact MOTs in the San Francisco Bay [3.17]~~[3.24]~~. Table 31F-3-6 ~~31F-3-8~~ provides values for the marine oil terminal locations within San Francisco Bay. Water levels could be positive or negative and current velocities may vary in direction. In order to determine the maximum run-up at a MOT, the largest values should be added to the mean high tide. Further details are available in [3.17]~~[3.24]~~.

Loads from tsunami-induced waves can be calculated for various structural configurations [3.18]~~[3.25]~~. …

3.31. ***TABLE 31F-3-6 ~~31F-3-8~~ TSUNAMI RUN-UP VALUES (ft) AND CURRENT SPEEDS (ft/sec) IN THE SAN FRANCISCO BAY AREA (AFTER [3.17]) ~~[AFTER 3.24]~~***

3.32. ***3103F.6.1 General.*** *Berthing loads are quantified in terms of transfer of kinetic energy of the vessel into potential energy dissipated by the fender(s). The terms and equations below are based on those in UFC 4-152-01 [3.19]~~, "Piers and Wharves" [3.26]~~ and PIANC [3.20]~~[3.27]~~.*

…

F_A = *Accidental factor accounting for abnormal conditions such as human error, malfunction, adverse environmental conditions or a combination of these factors. For existing berthing systems, F_A may be taken as 1.0. For new berthing systems, F_A shall be determined in accordance with Section 5-1.5.3 of UFC ~~Section~~ 4-152-01 [3.19]~~[3.26]~~ or PIANC Section 4.2.8 [3.20]~~[3.27]~~.*

…

The approximate displacement of the vessel (when only partially loaded) at impact, DT, can be determined from an extension of an equation from Gaythwaite [3.21]~~[3.28]~~:

…

For fender system selection, Section 3105F.4.5 shall be followed.

3.33. ***3103F.6.3 Geometric coefficient (C_g).*** *… Generally, 0.95 is recommended for the impact point at or beyond the quarter points of the ship, and 1.0 for broadside berthing in which contact is made along the straight side [3.19][3.26].*

3.34. ***3103F.6.5 Configuration coefficient (C_c) (C_e).*** *…*

…

For berths with different conditions, C_c may be interpolated between these values [3.19][3.26].

3.35. ***3103F.6.6 Effective mass or virtual mass coefficient (C_m).*** *…*

…

The value of C_m for use in design should be a minimum of 1.5 and need not exceed 2.0 [3.19][3.26].

3.36. ***3103F.6.7 Berthing velocity and angle.*** *…*

The berthing velocity, normal to berth, shall be in accordance with Table 31F-3-7 31F-3-9. Site condition is determined from Table 31F-3-8 31F-3-10.

…

… The berthing angles, used to compute the normal berthing velocity, for various vessel sizes are shown in Table 31F-3-9 31F-3-11.

3.37. ***TABLE 31F-3-7 31F-3-9 BERTHING VELOCITY V_n (NORMAL TO BERTH)[1]***

3.38. ***TABLE 31F-3-8 31F-3-10 SITE CONDITIONS***

3.39. Modify existing Table 31F-3-11 as following:

(1) ***TABLE 31F-3-9 31F-3-11 BERTHING ANGLE*** and

(2) Correct 2nd column title as follows: ***ANGLE (degrees) [degrees]***

3.40. ***3103F.7.2 Wind loads.*** *Chapter 29 6 of the ASCE/SEI 7 [3.5][3.11] shall be used to establish minimum wind loads on the structure. Additional information about wind loads may be obtained from Simiu and Scanlan [3.22][3.29].*

3.41. ***3103F.8 Load combinations.*** *As a minimum, each component of the structure shall be analyzed for all applicable load combinations given in Table 31F-3-10 ~~31F-3-12~~ or Table 31F-3-11 ~~31F-3-13~~, depending on component type. For additional load combinations, see ~~"Piers and Wharves," DOD~~ UFC 4-152-01 [3.19]~~[3.26]~~.*

…

3.42. ***TABLE 31F-3-10 ~~31F-3-12~~ LRFD LOAD FACTORS FOR LOAD COMBINATIONS [3.19]~~[3.26]~~***

3.43.

TABLE 31F-3-11 ~~31F-3-13~~

SERVICE OR ASD LOAD FACTORS FOR LOAD COMBINATIONS [3.19]~~[3.26]~~

LOAD TYPE	VACANT CONDITION	MOORING & BREASTING CONDITION	BERTHING CONDITION	EARTHQUAKE CONDITION	
Dead Load (D)	1.0	1.0	1.0	1+0.7k[1]	1-0.7k[1]
Live Load (L)	1.0	1.0	0.75	0.75	---
Buoyancy (B)	1.0	1.0	1.0	1.0	0.6
Wind on Structure (W)	1.0	1.0	0.75	---	---
Current on Structure (C)	1.0	1.0	1.0	---	---
Earth Pressure on the structure (H)	1.0	1.0	1.0	1.0	1.0
Mooring/Breasting Load (M)	---	1.0	---	---	---
Berthing Load (B_e)	---	---	1.0	---	---
Earthquake Load (E)	---	---	---	0.7	0.7
% Allowable Stress	100	100	100	100[2]	

1. *k = 0.5 (PGA)*
2. *Increase in allowable stress shall not be used with these load combinations unless it can be demonstrated that such increase is justified by structural behavior caused by rate or duration of load. See ASCE/SEI 7 [3.5]~~[3.11]~~*

3.44. ***3103F.8.2 Live load (L).*** *~~The~~ Typically, the live load on MOTs is ~~typically~~ small and may be ~~is therefore~~ neglected for combinations including earthquake loads. However, in some cases, a higher value of live load may be warranted depending on MOT use, and an appropriate value of live load shall be considered for combinations including earthquake loads.*

3.45. ***3103F.9 Safety factors for mooring lines.*** *Safety factors for different material types of mooring lines are given in Table 31F-3-12 ~~31F-3-14~~. …*

3.46.

TABLE 31F-3-12 31F-3-14

SAFETY FACTORS FOR ROPES [3.7] ROPES*

Steel Wire Rope	*1.82*
Polyamide	*2.22*
Nylon	*2.2*
Other Synthetic	*2.00*
Polyamide Tail for Wire Mooring Lines	*2.50*
Other Synthetic Tail for Wire Mooring Lines	*2.28*
Polyamide Tail for Synthetic Mooring Lines	*2.75*
Other Synthetic Tail for Synthetic Mooring Lines	*2.50*
Joining Shackles	*2.00*
Polyester Tail	*2.3*
Nylon Tail	*2.5*

**From Mooring Equipment Guidelines, OCIMF [3.30]*

3.47. ***3103F.10 Mooring hardware (N/E).*** *Mooring hardware shall include, but not be limited to, bollards, quick release hooks, other mooring fittings and base bolts. All mooring hardware fittings shall be clearly marked with their safe working loads (or allowable working loads) [3.7][3.13] (N). The certificate issued by the manufacturer normally defines the safe working loads of this hardware.*

3.48. ***3103F.10.2 Other fittings.*** *…*

If the allowable working loads for existing fittings are not available, the values listed in Table 31F-3-13 31F-3-15 may be used, for typical sizes, bolt patterns and layout. …

3.49.

TABLE 31F-3-13 ~~31F-3-15~~

ALLOWABLE WORKING LOADS

TYPE OF FITTINGS	*NO. OF BOLTS*	*BOLT SIZE (in)*	*WORKING LOAD (kips)*
30 in. Cleat	*4*	*1 1/8*	*20*
42 in. Cleat	*6*	*1 1/8*	*40*
Low Bitt	*10*	*1 5/8*	*60 per column*
High Bitt	*10*	*1 ¾*	*75 per column*
44 ½ in. Fit. Bollard	*4*	*1 ¾*	*70*
44 ½ in. Fit. Bollard	*8*	*2 ¼*	*200*
48 in. Fit. Bollard	*12*	*2 ¾*	*450*

Note: This table is modified from Table 6-11 of~~,~~ UFC 4-159-03 [3.10]~~[3.17]~~

3.50. *3103F.12 Symbols.*

a = …

A = *Site Class A as defined in Table 31F-6-1*

B = …

B = *Site Class B as defined in Table 31F-6-1*

B_1 = …

B_s = …

C = *Site Class C as defined in Table 31F-6-1*

C_b = …

...

C_t = …

D = *Site Class D as defined in Table 31F-6-1*

DSA = …

…

d_{max} = …

E = *Site Class E as defined in Table 31F-6-1*

E_{fender} = …

E_{vessel} = …

F = *Site Class F as defined in Table 31F-6-1*

F_a, F_v = *Site coefficients from Tables 31F-3-3 and 31F-3-4, respectively ~~31F-3-5 and 31F-3-6~~*

…

k = *Radius of longitudinal gyration of the vessel [ft]*

K = *Current velocity correction factor (Figure 31F-3-2) ~~(Fig 31F-3-4)~~*

~~*k* = *Radius of longitudinal gyration of the vessel [ft]*~~

PGA_X = *Peak ground acceleration corresponding to the s~~S~~ite c~~C~~lass under consideration~~.~~*

…

S_1 = *Spectral acceleration value (for the boundary of Site Classes B and C ~~S_B and S_C~~) at 1.0 second*

~~S_A-S_F = *Site classes as defined in Table 31F-6-1*~~

S_S = *Spectral acceleration value (for the boundary of Site Classes B and C ~~S_B and S_C~~) at 0.2 seconds*

S_{X1} = *Spectral acceleration value at 1.0 second corresponding to the period of S_1 and the s~~S~~ite c~~C~~lass under consideration*

S_{XS} = *Spectral acceleration value at 0.2 seconds corresponding to the period of S_S and the s~~S~~ite c~~C~~lass under consideration*

T = *Draft of vessel (Figure 31F-3-2) ~~(see Fig 31F-3-4)~~*

T = *Period [sec] ~~(Sec)~~*

…

WD = *Water Depth (Figure 31F-3-2) ~~(Fig 31F-3-4)~~*

3.51. *3103F.13 References.*

[3.1] Federal Emergency Management Agency (FEMA)~~, FEMA-356~~, Nov. 2000, FEMA 356, "Prestandard and Commentary for the Seismic Rehabilitation of Buildings," Washington, D.C.

~~*[3.2] California Geological Survey, 2003, "Seismic Shaking Hazards in California," Sacramento, CA.*~~

~~*[3.3] Idriss, I.M., August 1985, "Evaluating Seismic Risk in Engineering Practice," Proceedings, Theme Lecture No. 6, XI International Conference on Soil Mechanics and Foundation Engineering, San Francisco, CA, vol. I, pp. 255-320.*~~

~~*[3.4] Southern California Earthquake Center (SCEC), March 1999, "Recommended Procedures for Implementation of DMG Special Publication 117 Guidelines for Analyzing and Mitigating Liquefaction in California," University of Southern California, Los Angeles.*~~

~~*[3.5] Earth Mechanics, Inc., "Port-Wide Ground Motion and Palos Verdes Fault Study – Port of Los Angeles, California, FINAL REPORT," December 22, 2006, Fountain Valley, CA.*~~

~~*[3.6] Earth Mechanics, Inc., "Port-Wide Ground Motion Study – Port of Long Beach, California, FINAL REPORT," August 7, 2006, Fountain Valley, CA.*~~

~~*[3.7] Savy, J. and Foxall, W, 2002, "Probabilistic Seismic Hazard Analysis for Southern California Coastal Facilities," 2003, Lawrence Livermore National Laboratory.*~~

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[3.3~~9~~] Somerville, Paul G., Smith, Nancy F., Graves, Robert W., and Abrahamson, Norman A., 1997, "Modification of Empirical Strong Ground Motion Attenuation Relations to Include the Amplitude and Duration Effects of Rupture Directivity", Seismological Research Letters, Volume 68, Number 1, pp.199-222.

[3.4~~10~~] California Code of Regulations (CCR), ~~"Marine Terminals, Inspection and Monitoring,"~~ Title 2, Division 3, Chapter 1, Article 5 – Marine Terminals Inspection and Monitoring (2 CCR 2300 et seq.)~~. California State Lands Commission, Sacramento, CA.~~

[3.5~~11~~] American Society of Civil Engineers (ASCE), 2010, ASCE/SEI 7-10 (ASCE/SEI 7)~~, Jan. 2000~~, "Minimum Design Loads for Buildings and Other Structures," ~~ASCE 7-98, Revision of ANSI/ASCE 9-95,~~ Reston, VA.

[3.6~~12~~] Pile Buck Inc. ~~Production~~, 1992, "Mooring Systems, A Pile Buck Production," ~~Pile Buck Inc.,~~ Jupiter, FL ~~Florida~~.

[3.7~~13~~] Oil Companies International Marine Forum (OCIMF), 2008, "Mooring Equipment Guidelines (MEG3)," 3rd ed., London, England.

~~*[3.14] British Standards Institution, 2000, "British Standard Code of Practice for Maritime Structures - Part 1 General Criteria" BS6349, Part 1, London, England.*~~

[3.8~~15~~] Ferritto, J., Dickenson, S., Priestley N., Werner, S., Taylor, C., Burke, D., Seelig, W., and Kelly, S., 1999, "Seismic Criteria for California Marine Oil Terminals," Vol. 1 and Vol. 2, Technical Report TR-2103-SHR, Naval Facilities Engineering Service Center, Port Hueneme, CA.

[3.9~~16~~] National Oceanic and Atmospheric Administration, Contact: National PORTS Program

Manager, Center for Operational Oceanographic Products and Services, 1305 EW Highway, Silver Spring, MD 20910.

[3.10~~17~~] Department ~~Dept.~~ of Defense, 3 October 2005 (Revised 1 September 2012), Unified Facilities Criteria (UFC) 4-159-03, "Design: Moorings," Washington, D.C.

[3.11~~18~~] Chakrabarti, S. K., 1987, "Hydrodynamics of Offshore Structures," Computational Mechanics.

[3.12~~19~~] Kriebel, David, "Mooring Loads Due to Parallel Passing Ships,"~~,~~ Technical Report TR-6056-OCN, US Naval Academy, 30 September 2005.

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[3.18~~25~~] Camfield, Frederick E., February 1980, "Tsunami Engineering," U.S. Army, Corps of Engineers, Coastal Research Center, Special Report No. 6.

[3.19~~26~~] Department ~~Dept.~~ of Defense, 28 July 2005 (Revised 1 September 2012), "Design: Piers and Wharves," Unified Facilities Criteria (UFC) 4-152-01~~, 28 July 2005~~, Washington, D.C.

[3.20~~27~~] Permanent International Association of Navigation Congresses (PIANC), 2002, "Guidelines for the Design of Fender Systems: 2002," Brussels.

[3.21~~28~~] Gaythwaite, John, 2004, "Design of Marine Facilities for the Berthing, Mooring and Repair of Vessels," American Society of Civil Engineers, Reston, VA.

[3.22~~29~~] Simiu, E. and Scanlan, R., 1978, "Wind Effects on Structures: An Introduction to Wind Engineering," Wiley-Interscience Publications, New York.

Authority: Sections 8750 through 8760 ~~8755 and 8757~~, Public Resources Code.

Reference: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

Notation
Authority: Sections 8750 through 8760, Public Resources Code.
References: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

DIVISION 4
SECTION 3104F
SEISMIC ANALYSIS AND STRUCTURAL PERFORMANCE

4.1. ~~***3104F.1.3 Oil spill risk classification.*** *Each existing MOT shall be catagorized into one of three risk classifications (high, moderate or low) as shown in Table 31F-4-1, based on the following:*~~

~~*1. Exposed total volume of oil during transfer ("total volume" as calculated in Section 3108F.2.3)*~~

~~*2. Number of oil transfer operations per berthing system per year*~~

~~*3. Maximum vessel size (DWT) that may call at the berthing system*~~

~~*If risk reduction strategies (see Section 3101F.5) are adopted such that the maximum volume of exposed oil during transfer is less than 1,200 barrels, the classification level of the facility may be lowered. All new MOTs are classified as high risk.*~~

4.2. Remove entirely: ~~***TABLE 31F-4-1 MOT RISK CLASSIFICATION***~~

4.3. ***3104F.1.3~~4~~ Configuration classification.*** *Each MOT shall be designated as regular or irregular based on torsional irregularity criteria presented in ASCE/SEI 7 [4.1]~~, in accordance with Figure 31F-4-1~~. An MOT is defined to be irregular when maximum displacement at one end of the MOT transverse to an axis is more than 1.2 times the average of the displacement at the two ends of the MOT as described in Figure 31F-4-1. For MOTs with multiple segments separated by expansion joints, each segment shall be designated as regular or irregular using criteria in this section. Expansion joints in this context are defined as joints that separate each structural segment in such a manner that each segment will move independently during an earthquake.*

~~*Irregular configurations, such as the "T" layout, may be analyzed as regular if the presence of expansion joints divides the T-configuration into two or more regular segments. Expansion joints in this context are defined as joints that separate each structural segment in such a manner that each segment will move independently during an earthquake.*~~

If an ~~irregular~~ MOT is divided into seismically isolated sections, an evaluation of the relative movement of pipelines and supports shall be considered, including phase differences (Section 3109F.3).

4.4. Remove entirely: ~~***FIGURE 31F-4-1 PIER AND WHARF CONFIGURATIONS***~~

4.5. Add new Figure 31F-4-1:

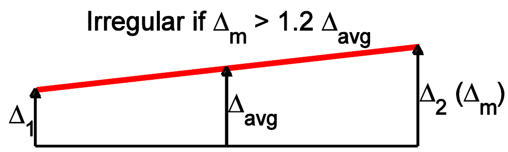


FIGURE 31F-4-1 DEFINITION OF IRREGULAR MOT

4.6. WITHDRAWN – The originally proposed revisions to Section 3104F.2.1 "Design earthquake motions" are withdrawn. See FSOR for additional information.

4.7.

TABLE 31F-4-1 ~~31F-4-2~~

SEISMIC PERFORMANCE CRITERIA [1, 2]

SPILL ~~RISK~~ CLASSIFICATION [3]	***SEISMIC PERFORMANCE LEVEL***	***PROBABILITY OF EXCEEDANCE***	***RETURN PERIOD***
High	*Level 1*	*50% in 50 years*	*72 years*
	Level 2	*10% in 50 years*	*475 years*
Moderate	*Level 1*	*65% in 50 years*	*48 years*
	Level 2	*15% in 50 years*	*308 years*
Low	*Level 1*	*75% in 50 years*	*36 years*
	Level 2	*20% in 50 years*	*224 years*

1. For new MOTs, see Section 3104F.3.
2. For marine terminals transferring LNG, return periods of 72 and 475 years shall be used for Levels 1 and 2, respectively.
3. See Section 3101F.6 for spill classification.

4.8. ***3104F.2.3 Analytical procedures.*** *The objective of the seismic analysis is to verify that the displacement capacity of the structure is greater than the displacement demand, for each performance level defined in Table 31F-4-1 ~~31F-4-2~~. For this purpose, the displacement capacity of each element of the structure shall be checked against its displacement demand including the orthogonal effects of Section 3104F.4.2. The required analytical procedures are summarized in Table 31F-4-2 ~~31F-4-3~~.*

The displacement capacity of the structure shall be calculated using the nonlinear static (pushover) procedure. For the nonlinear static (pushover) procedure, the pushover load shall be applied at the target node defined as the center of mass (CM) of the MOT structure. It is also acceptable to use a nonlinear dynamic procedure for capacity evaluation, subject to peer review in accordance with Section 3101F.8.2.

Methods used to calculate the displacement demand are linear modal, nonlinear static and nonlinear dynamic.

Mass to be included in the displacement demand calculation shall include mass from self-weight of the structure, weight of the permanent equipment, and portion of the live load that may contribute to *inertial mass during earthquake loading, such as a minimum of 25% of the floor live load in areas used for storage.*

Any rational method, subject to the Division's approval, can be used in lieu of the required analytical procedures shown in Table 31F-4-2 31F-4-3.

4.9.

TABLE 31F-4-2 31F-4-3

MINIMUM REQUIRED ANALYTICAL PROCEDURES

SPILL RISK CLASSIFICATION[1]	CONFIGURATION	SUBSTRUCTURE MATERIAL	DISPLACEMENT DEMAND PROCEDURE	DISPLACEMENT CAPACITY PROCEDURE
High/Moderate	Irregular	Concrete/Steel	Linear Modal	Nonlinear Static
High/Moderate	Regular	Concrete/Steel	Nonlinear Static[2]	Nonlinear Static
Low	Regular/Irregular	Concrete/Steel	Nonlinear Static	Nonlinear Static
High/Moderate/Low	Regular/Irregular	Timber	Nonlinear Static	Nonlinear Static

1. See Section 3101F.6 for spill classification.

2. Linear modal demand procedure may be required for cases where more than one mode is expected to contribute to the displacement demand.

4.10. ***3104F.2.3.1 Nonlinear static capacity procedure (pushover).*** *To assess displacement capacity, tTwo-dimensional nonlinear static (pushover) analyses shall be performed; three-dimensional analyses are optional. A model that incorporates the nonlinear load deformation characteristics of all components for the lateral force-resisting system shall be used in the pushover analysis. displaced to a target displacement to determine the internal deformations and forces. The target displacement depends on the seismic performance level under consideration. Modeling details are as follows:*

Alternatively, displacement capacity of a pile in the MOT structure may be estimated from pushover analysis of an individual pile with appropriate axial load and pile-to-deck connection.

The displacement capacity of a pile from the pushover analysis shall be defined as the displacement that can occur at the top of the pile without exceeding plastic rotation (or material strain) limits, either at the pile-deck hinge or in-ground hinge, as defined in Section 3107F. If pile displacement has components along two axes, as may be the case for irregular MOTs, the pile displacement capacity shall be defined as the resultant of its displacement components along the two axes.

4.11. ***3104F.2.3.1.1 Modeling.*** *A series of nonlinear pushover analyses may be required depending on the complexity of the MOT structure. At a minimum, pushover analysis of a two-dimensional model shall be conducted in both the longitudinal and transverse directions. The piles shall be represented by nonlinear elements that capture the moment-curvature/rotation relationships for components with expected inelastic behavior in accordance with Section 3107F. The effects of connection flexibility shall be considered in pile-to-deck connection modeling. For prestressed concrete piles, Figure 31F-4-2 may be used. A nonlinear element is not required to represent each pile location. Piles with similar lateral force-deflection behavior may be lumped in fewer larger springs provided that the overall torsional effects are captured.*

…

4.12. Add new Figure 31F-4-2:

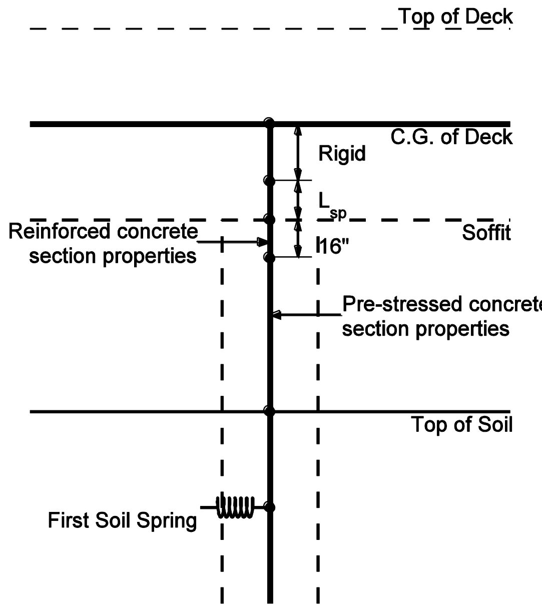


FIGURE 31F-4-2
PILE-DECK CONNECTION MODELING FOR
PRESTRESSED CONCRETE PILE
(ADAPTED FROM [4.2])

4.13. ***3104F.2.3.1.2 Timber pile supported structures.*** *…*

A simplified single pile model for a typical timber pile supported structure is shown in Figure 31F-4-3 ~~31F-4-2~~. …

…

4.14. ***FIGURE 31F-4-3 ~~31F-4-2~~ – SIMPLIFIED SINGLE PILE MODEL OF A TIMBER PILE SUPPORTED STRUCTURE***

4.15. ~~***3104F.2.3.1.3 Soil-structure interaction (SSI).*** *Load-deformation characteristics for foundations shall be modeled as per Section 3106F.5. Selection of soil springs shall be based on the following:*~~

~~*1. Effect of the large difference in up and down slope stiffnesses for wharf type structures*~~

~~*2. Effect of upper and lower bound soil parameters, especially for t-z curves used to model batter pile behavior*~~

~~*A separate analysis that captures the demand (Section 3104F.2.3.2) on the piles due to permanent ground deformations, at embankments only, shall be performed.*~~

If a simplified methodology is followed, the piles need to be checked for the following load combinations:

$$1.0\,E_{inertial}$$

$$1.0H_d + 0.25E_{inertial}$$

where:

$E_{inertial}$ = *Inertial seismic load*

H_d = *Foundation deformation load*

4.16. ***3104F.2.3.2 Nonlinear static demand procedure.*** *A nonlinear static procedure shall be used to determine the displacement demand for all concrete and steel structures, with the exception of irregular configurations with high or moderate spill seismic risk classifications. The following Sections (3104F.2.3.2.1 through 3104F.2.3.4) describe the procedure of Priestly et al. [4.1]; an alternate procedure is presented in ATC 40 [4.2], which is improved in FEMA 440 [4.3]. A linear modal procedure is required for irregular structures with high or moderate spill seismic risk classifications, and may be used for all other classifications in lieu of the nonlinear static procedure.*

In the nonlinear static demand procedure, deformation demand in each element shall be computed at the target node displacement demand. The analysis shall be conducted in each of the two orthogonal directions and results combined as described in Section 3104F.4.2.

The target displacement demand of the structure, Δ_d, shall be calculated by multiplying the spectral response acceleration, S_A, corresponding to the effective elastic structural period, T_e (see Equation (4-2) or Equation (4-8)), by $T_e^2/4\pi^2$. $\Delta_d = S_A\left(T_e^2/4\pi^2\right)$. If $T_e<T_0$, where T_0 is the period corresponding to the peak of the acceleration response spectrum, a refined analysis (see Section 3104F.2.3.2.1 or 3104F.2.3.2.2) shall be used to calculate the displacement demand. In the refined analysis, the target node displacement demand may be computed from the Coefficient Method of ASCE/SEI 41 [4.3] that is based on the procedure presented in FEMA 440 [4.6], or the Substitute Structure Method presented in Priestley et al. [4.4]. Both of these methods utilize the pushover curve developed in Section 3104F.2.3.1.

4.17. ***3104F.2.3.2.1 Lateral stiffness.*** *The lateral stiffness, k, is calculated from the force-displacement relation as the total base shear, V_y, corresponding to the yield displacement of the structure Δ_y. Δ_y is the displacement at first yield in the pile/deck connection reinforcement.*

4.18. ***3104F.2.3.2.1 Coefficient Method.*** *The Coefficient Method is based on the ASCE/SEI 41 [4.3] procedure.*

The first step in the Coefficient Method requires idealization of the pushover curve to calculate the effective elastic lateral stiffness, k_e, and effective yield strength, F_y, of the structure as shown in Figure 31F-4-4.

The first line segment of the idealized pushover curve shall begin at the origin and have a slope equal to the effective elastic lateral stiffness, k_e. The effective elastic lateral stiffness, k_e, shall be taken as the secant stiffness calculated at the lateral force equal to 60 percent of the effective yield strength, F_y, of the structure. The effective yield strength, F_y, shall not be taken as greater than the maximum lateral force at any point along the pushover curve.

The second line segment shall represent the positive post-yield slope ($\alpha_1 k_e$) determined by a point (F_d, Δ_d) and a point at the intersection with the first line segment such that the area above and below the actual curve area approximately balanced. (F_d, Δ_d) shall be a point on the actual pushover curve at the calculated target displacement, or at the displacement corresponding to the maximum lateral force, whichever is smaller.

The third line segment shall represent the negative post-yield slope ($\alpha_2 k_e$), determined by the point at the end of the positive post-yield slope (F_d, Δ_d) and the point at which the lateral force degrades to 60 percent of the effective yield strength.

The target displacement shall be calculated from:

$$\Delta_d = C_1 C_2 S_A \frac{T_e^2}{4\pi^2} \qquad (4\text{-}1)$$

where:

S_A = *spectral acceleration of the linear-elastic system at vibration period, which is computed from:*

$$T_e = 2\pi \sqrt{\frac{m}{k_e}} \qquad (4\text{-}2)$$

where:

m = *seismic mass as defined in Section 3104F.2.3*

k_e = *effective elastic lateral stiffness from idealized pushover*

C_1 = *modification factor to relate maximum inelastic displacement to displacement calculated for linear elastic response. For period less than 0.2 s, C_1 need not be taken greater than the value at T_e = 0.2 s. For period greater than 1.0 s, C_1 = 1.0. For all other periods:*

$$C_1 = 1 + \frac{\mu_{strength} - 1}{a T_e^2} \qquad (4\text{-}3)$$

where:

a = *Site class factor*

= *130 for Site Class A or B,*

= 90 for Site Class C, and

= 60 for Site Class D, E, or F.

$\mu_{strength}$ = ratio of elastic strength demand to yield strength coefficient calculated in accordance with Equation (4-5). The Coefficient Method is not applicable where $\mu_{strength}$ exceeds $\mu_{\max}$ computed from Equation (4-6).

C_2 = modification factor to represent the effects of pinched hysteresis shape, cyclic stiffness degradation, and strength deterioration on the maximum displacement response. For periods greater than 0.7s, C_2 =1.0. For all other periods:

$$C_2 = 1 + \frac{1}{800}\left(\frac{\mu_{strength} - 1}{T_e}\right)^2 \qquad (4\text{-}4)$$

The strength ratio $\mu_{strength}$ shall be computed from:

$$\mu_{strength} = \frac{mS_A}{F_y} \qquad (4\text{-}5)$$

where:

F_y = yield strength of the structure in the direction under consideration from the idealized pushover curve.

For structures with negative post-yield stiffness, the maximum strength ratio $\mu_{\max}$ shall be computed from:

$$\mu_{\max} = \frac{\Delta_d}{\Delta_y} + \frac{\left|\alpha_e\right|^{-h}}{4} \qquad (4\text{-}6)$$

where:

Δ_d = larger of target displacement or displacement corresponding to the maximum pushover force,

Δ_y = displacement at effective yield strength,

$h = 1 + 0.15 \ln T_e$, and

α_e = effective negative post-yield slope ratio which shall be computed from:

$$\alpha_e = \alpha_{P-\Delta} + \lambda\left(\alpha_2 - \alpha_{P-\Delta}\right) \qquad (4\text{-}7)$$

where:

$\alpha_{P-\Delta}$, and the maximum negative post-elastic stiffness ratio, α_2, are estimated from the idealized force-deformation curve, and λ is a near-field effect factor equal to 0.8 for sites with 1 second spectral value, S_1 greater than or equal to 0.6g and equal to 0.2 for sites with 1 second spectral value, S_1 less than 0.6g.

4.19. Add new Figure 31F-4-4:

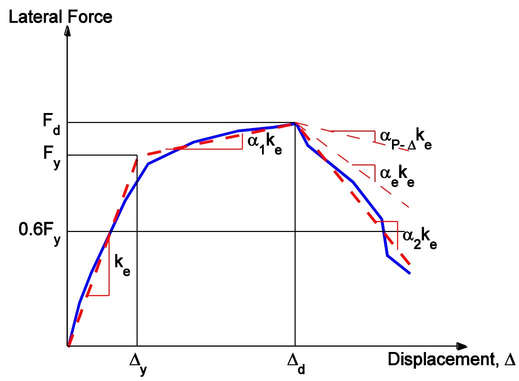


FIGURE 31F-4-4
IDEALIZATION OF PUSHOVER CURVE (ADAPTED FROM [4.3])

4.20. ~~***3104F.2.3.2.2 Structural period.*** *The fundamental period, T, of the structure in the direction under consideration shall be calculated as follows:*~~

$$\require{cancel}\cancel{T = 2\pi\sqrt{\frac{m}{k}}} \qquad (4\text{-}1)$$

~~***where:***~~

~~*m = mass of structure in kips/g*~~

~~*k = stiffness in direction under consideration in kips/ft*~~

~~*g = gravity, 32 ft/sec² (9.8 meters/sec²)*~~

4.21. ~~***3104F.2.3.2.3 Target displacement demand.*** *The target displacement demand of the structure, Δ_d, can be calculated by multiplying the spectral response acceleration, S_A, corresponding to the period, T, by $T^2/4\pi^2$.*~~

$$\cancel{\Delta_d = S_A \frac{T^2}{4\pi^2}} \qquad (4\text{-}2)$$

~~*If $T < T_o$, where T_o is the period corresponding to the peak of the acceleration response spectrum, a refined analysis (see Section 3104F.2.3.2.5) shall be used to calculate the displacement demand. Multidirectional excitation shall be addressed per Section 3104F.4.2.*~~

4.22. ~~***3104F.2.3.2.4 Damping.*** *The displacement demand established in Section 3104F.2.3.2.3 is based on 5 percent damping. Higher damping values obtained from a refined analysis may be used to calculate the displacement demand.*~~

4.23. ~~***3104F.2.3.2.5 Refined analyses.*** *Refined displacement demand analyses may be calculated as per Chapters 4 and 5 of [4.1] and is briefly summarized below.*~~

3104F.2.3.2.2 Substitute Structure Method. *The Substitute Structure Method is based on the procedure presented in Priestley et al. [4.4] and is briefly summarized below.*

1. *Idealize the pushover curve from nonlinear pushover analysis, as described in Section 3104F.2.3.2.1, and estimate the yield force, F_y, and yield displacement, Δ_y.*
2. *Compute the effective elastic lateral stiffness, k_e, as the yield force, F_y, divided by the yield displacement, Δ_y.*
3. *Compute the structural period in the direction under consideration from:*

$$T_e = 2\pi\sqrt{\frac{m}{k_e}} \qquad (4\text{-}8)$$

where:

m = seismic mass as defined in Section 3104F.2.3

k_e = effective elastic lateral stiffness in direction under consideration

4~~1~~. Determine target displacement Δ_d, from: ~~Section 3104F.2.3.2.3.~~

$$\Delta_d = S_A \frac{T_e^2}{4\pi^2} \qquad (4\text{-}9)$$

where:

S_A = spectral displacement corresponding to structural period, T_e

~~*2. From the nonlinear pushover analysis, determine the structural yield displacement Δ_y.*~~

5~~3~~. The ductility level, μ_Δ, is found from Δ_d/Δ_y. Use the appropriate relationship between ductility and damping, for the component undergoing inelastic deformation, to estimate the effective structural damping, ξ_{eff}. In lieu of more detailed analysis, the relationship shown in Figure 31F-4-5 ~~31F-4-3~~ or Equation (4-10) ~~equation (4-3)~~ may be used for concrete and steel piles connected to the deck through dowels embedded in the concrete.

$$\xi_{eff} = 0.05 + \frac{1}{\pi}\left(1 - \frac{1-r}{\sqrt{\mu_\Delta}} - r\sqrt{\mu_\Delta}\right) \qquad (4\text{-}10)\ \text{~~(4-3)~~}$$

where:

r = ratio of second slope over elastic slope (see Figure 31F-4-7 ~~31F-4-5~~)

Equation (4-10) for effective damping was developed by Kowalsky et al. [4.5] for the Takeda hysteresis model of system's force-displacement relationship.

64. From the acceleration response spectra, create elastic displacement spectra, S_D, using Equation (4-11) equation (4-4) for various levels of damping.

$$S_D = \frac{T^2}{4\pi^2} S_A \qquad (4\text{-}11)(4\text{-}4)$$

75. Using the curve applicable to the effective structural damping, ξ_{eff}, ξ, find the effective period, T_d (see Figure 31F-4-6 31F-4-4).

86. In order to convert from a design displacement response spectra to another spectra for a different damping level, the adjustment factors in Section 3103F.4.2.9 shall be used.

97. The effective secant stiffness, k_{eff}, k_e, can then be found from:

$$k_{eff} = \frac{4\pi^2}{T_d^2} m \qquad (4\text{-}12)$$

$$k_e = \frac{4\pi^2}{T_d^2} M \qquad (4\text{-}5)$$

where:

m = seismic mass as defined in Section 3104F.2.3

M = mass of deck considered in the analysis.

T_d = effective structural period

108. The required strength, F_u, can now be estimated by:

$$F_u = k_{eff}\Delta_d \qquad (4\text{-}13)\ (4\text{-}6)$$

119. F_u and Δ_d can be plotted on the force-displacement curve established by the pushover analysis. Since this is an iterative process, the intersection of F_u and Δ_d most likely will not fall on the force-displacement curve and a second iteration will be required. An adjusted value of Δ_d, taken as the intersection between the force-displacement curve and a line between the origin and F_u and Δ_d, can be used to find μ_Δ.

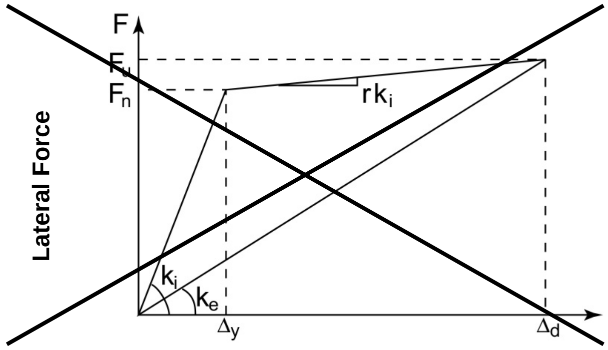
1210. Repeat the process until a satisfactory solution is obtained (see Figure 31F-4-7 31F-4-5).

13. From pushover data, calculate the displacement components of an element along the two axis of the system.

4.24. FIGURE 31F-4-5 31F-4-3 RELATION BETWEEN DUCTILITY, μ_Δ, AND EFFECTIVE DAMPING, ξ_{eff} [4.5][4.1]

4.25. FIGURE 31F-4-6 31F-4-4 DESIGN DISPLACEMENT RESPONSE SPECTRA

4.26. Remove entirely:



~~FIGURE 31F-4-5~~
~~EFFECTIVE STIFFNESS, k_e [4.1]~~

4.27. Add new Figure 31F-4-7:

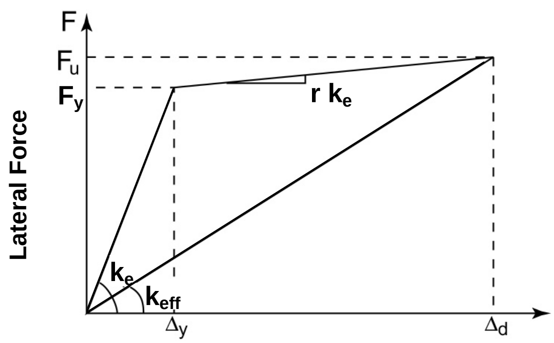


FIGURE 31F-4-7
EFFECTIVE LATERAL STIFFNESS (ADAPTED FROM [4.4])

4.28. ***3104F.2.3.3 Linear modal demand procedure.*** *For irregular concrete/steel structures with moderate or high spill ~~risk~~ classifications, a linear modal analysis is required to predict the global displacement demands. A 3-D linear elastic response analysis shall be used, with effective moment of inertia applied to components to establish lateral displacement demands, to compute displacement components of an element along each axis of the system.*

Sufficient modes shall be included in the analysis such that 90 percent of the participating mass is captured in each of the principal horizontal directions for the structure. For modal combinations, the C~~c~~omplete Q~~q~~uadratic C~~c~~ombination rule shall be used. Multidirectional excitation shall be accounted for in accordance with Section 3104F.4.2.

The lateral stiffness of the linear elastic response model shall be based on the initial stiffness of the nonlinear pushover curve as shown in Figure 31F-4-8 ~~31F-4-6~~ (also see Section 3106F.9 ~~3106F.5.1~~). The p-y springs shall be adjusted based on the secant method approach. Most of the p-y springs will typically be based on their initial stiffness; no iteration is required.

If the fundamental period is $T<T_0$, where T_0 is the period corresponding to the peak of the acceleration response spectrum, the displacement demand from the linear modal analysis shall be amplified to account for nonlinear system behavior by an amplification factor. The amplification factor shall be equal to either $C_1 \times C_2$ per Section 3104F.2.3.2.1, or the ratio of the final target displacement and the initial elastic displacement of Equation (4-9) per Section 3104F.2.3.2.2.

~~If the fundamental period in the direction under consideration is less than T_o, as defined in Section 3104F.2.3.2.3, then the displacement demand shall be amplified as specified in Section 3104F.2.3.2.5.~~

4.29. *FIGURE 31F-4-8 ~~31F-4-6~~ STIFFNESS FOR LINEAR MODAL ANALYSIS*

4.30. ***3104F.2.3.4 Nonlinear dynamic analysis.*** *Nonlinear dynamic time history analysis is optional, and if performed, a peer review is required (see Section 3101F.8.2 ~~3101F.6.1~~). …*

…

4.31. ***3104F.2.3.5 Alternative procedures.*** *… As per Section 3101F.8.2 ~~3101F.6.1~~, peer review is required.*

4.32. ***3104F.3 New MOTs.*** *The analysis and design requirements described in Section 3104F.2 shall also apply to new MOTs. However, new MOTs shall comply with the seismic performance criteria for high spill classification, as defined in Table 31F-4-1. Additional requirements are as follows:*

1. *Site-specific response spectra analysis (see Section 3103F.4.2.3).*
2. *Soil parameters based on site-specific and new borings (see Section 3106F.2.2).*

4.33. ***3104F.4.2 Combination of orthogonal seismic effects.*** *The design displacement demand at an element, δ_d, ~~Δ_d~~, shall be calculated by combining the longitudinal, δ_x, ~~Δ_x~~, and transverse, δ_y, ~~Δ_y~~, displacements in the horizontal plane (Figure 31F-4-9 ~~31F-4-7~~):*

$$\delta_d = \sqrt{\delta_x^2 + \delta_y^2} \qquad (4\text{-}14)$$

where:

$$\delta_x = \delta_{xy} + 0.3\delta_{xx} \qquad (4\text{-}15)$$

and

$$\delta_y = 0.3\delta_{yx} + \delta_{yy} \qquad (4\text{-}16)$$

OR

$$\delta_y = \delta_{yx} + 0.3\delta_{yy} \qquad (4\text{-}17)$$

and

$$\delta_x = 0.3\delta_{xy} + \delta_{xx} \qquad (4\text{-}18)$$

~~$$\Delta_d = \sqrt{\Delta_x^2 + \Delta_y^2} \qquad (4\text{-}7)$$~~

~~***where:***~~

~~$$\Delta_x = \Delta_{xy} + 0.3\Delta_{xx} \qquad (4\text{-}8)$$~~

~~*and*~~

~~$$\Delta_y = 0.3\Delta_{yx} + \Delta_{yy} \qquad (4\text{-}9)$$~~

~~*or*~~

~~$$\Delta_y = \Delta_{yx} + 0.3\Delta_{yy} \qquad (4\text{-}10)$$~~

~~*and*~~

~~$$\Delta_x = 0.3\Delta_{xy} + \Delta_{xx} \qquad (4\text{-}11)$$~~

whichever results in the greater design displacement demand.

~~*In lieu of combining the displacement demands as presented above, the design displacement demand for marginal wharf type MOTs may be calculated as:*~~

~~$$\Delta_d = \Delta_y \sqrt{1 + (0.3(1 + 20e/L_l))^2} \qquad (4\text{-}12)$$~~

~~***where:***~~

~~Δ_y = *transverse displacement demand*~~

~~e = *eccentricity between center of mass and center of rigidity*~~

~~L_l = *longitudinal length between wharf expansion*~~

~~*This equation is only valid for wharf aspect ratios (length/breadth) greater than 3.*~~

4.34. Remove entirely: ~~***FIGURE 31F-4-7 PLAN VIEW OF WHARF SEGMENT UNDER X AND Y SEISMIC EXCITATIONS [4.3]***~~

4.35. Add new Figure 31F-4-9:

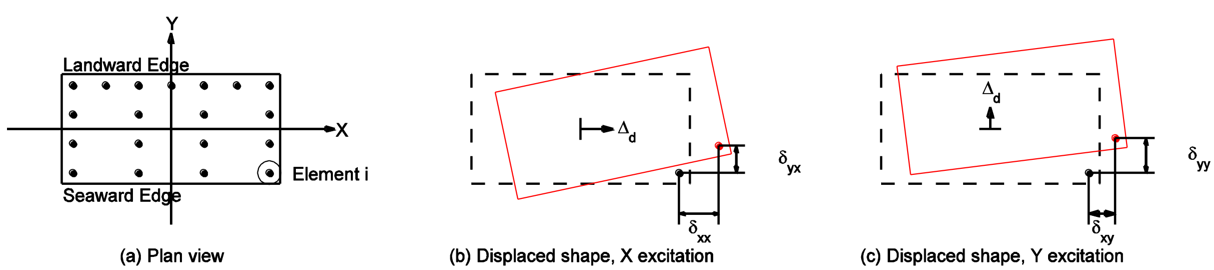


FIGURE 31F-4-9
PLAN VIEW OF WHARF SEGMENT UNDER X AND Y SEISMIC EXCITATIONS

4.36. ***3104F.4.3 P-Δ Effects.*** *The P-Δ effect (i.e., the additional moment induced by the total vertical load multiplied by the lateral deck deflection) shall be considered unless the following relationship is satisfied (see Figure 31F-4-10 ~~31F-4-8~~):*

$$\frac{V}{W} \geq 4\frac{\Delta_d}{H} \qquad (4\text{-}19)\ \sout{(4\text{-}13)}$$

…

4.37. ***FIGURE 31F-4-10 ~~31F-4-8~~ P-Δ EFFECT***

4.38. ***3104F.4.5 Shear key forces.*** *Shear force across shear keys connecting adjacent wharf segments, V_{sk}, (approximate upper bound to the shear key force [4.7]~~[4.4]~~) shall be calculated as follows:*

$$V_{sk} = 1.5(e/L_l)V_{\Delta T} \qquad (4\text{-}20)\ \sout{(4\text{-}14)}$$

…

4.39. ***3104F.4.7 Batter piles.*** *... Failure in tension may be dictated by connection strength or by pile pull out (p. 3-83 of Ferritto et al. [4.7]) ~~(p. 3-83 of [4.4])~~.*

…

... This procedure allows the pile to deform axially before reaching ultimate loads, thereby increasing the displacement ductility [4.7]~~[4.4]~~.

...

4.40. ***3104F.5.2 Seismic assessment ~~loads~~.*** *In general, for nonstructural components, the evaluation procedures of Section 3110F.8 apply ~~are adequate~~.*

...

~~*A pipeline segment under consideration shall extend between two adjacent anchor points. A simplified pipeline analysis may be used when the relative displacement demands of anchor points are considered. As an option, a full nonlinear time-history analysis can be used to capture the nonlinear interaction between the structure and the pipeline.*~~

4.41. ***3104F.6~~5.3~~ Nonstructural critical systems assessment.*** *A seismic assessment of the survivability and continued operation during a Level 2 earthquake (see Table 31F-4-1 ~~31F-4-2~~) shall be performed for critical systems such as fire protection, emergency shutdown and electrical power systems. The assessment shall consider the adequacy and condition of anchorage, flexibility and seismically-induced interaction. For existing systems, seismic adequacy may be assessed per CalARP [4.8]~~[4.5]~~.*

4.42. *3104F.7~~6~~ Symbols.*

a	=	*Site class factor*
C_1	=	*Modification factor to relate expected maximum inelastic displacement to displacement calculated for linear elastic response*
C_2	=	*Modification factor to represent the effects of pinched hysteresis shape, cyclic stiffness degradation and strength deterioration on the maximum displacement response*
e	=	…
~~$E_{inertial}$~~	=	~~*Inertial seismic load*~~
F_u	=	…
F_y	=	*Effective yield strength*
H	=	…
~~H_d~~	=	~~*Foundation deformation load*~~
~~k~~	=	~~*Stiffness in direction under consideration in k/ft*~~
k_e	=	*Effective elastic lateral stiffness*
k_{eff}	=	*Effective secant lateral stiffness*
L_l	=	…
m	=	*Seismic mass* ~~*Mass of structure in kips/g*~~
~~M~~	=	~~*Mass of deck considered in the analysis*~~
r	=	…
S_A	=	*Spectral response acceleration~~,~~ at T*
S_D	=	*Displacement response spectrum~~,~~ at T*
~~S_{ap}~~	=	~~*Spectral response acceleration of pipeline segment under consideration*~~
S_1	=	*1-second spectral response acceleration*
T	=	…
T_d	=	…
T_e	=	*Effective elastic structural period*
V	=	…
~~V_y~~	=	~~*total base shear*~~
~~$V_{\ddot{A}T}$~~	=	~~*total segment lateral force*~~
V_{sk}	=	…
$V_{\Delta T}$	=	*Total segment lateral force*
W	=	…
~~W_p~~	=	~~*Weight of pipeline segment under consideration*~~
α_1	=	*Positive post-yield slope ratio equal to positive post-yield stiffness divided by the effective stiffness*
α_2	=	*Negative post-yield slope ratio equal to negative post-yield stiffness divided by the effective stiffness*
α_e	=	*Effective negative post-yield slope ratio equal to effective post-yield negative stiffness divided by the effective stiffness*
$\alpha_{P\text{-}\Delta}$	=	*Negative slope ratio caused by P-Δ effects*

Δ_{avg} = *Average of displacements, Δ_1, Δ_2, at ends of the MOT transverse to an axis*

Δ_d = *Target Design displacement demand*

Δ_m = *Maximum of displacements, Δ_1 and Δ_2, at ends of the MOT transverse to an axis*

Δ_y = *Displacement at yield strength*

Δ_1, Δ_2 = *Displacement at ends of the MOT transverse to an axis*

δ_d Δ_x = *Design displacement demand at an element Longitudinal displacement demand*

δ_x = *Displacement of an element in X direction*

δ_y = *Displacement of an element in Y direction*

δ_{xx} Δ_{xx} = …

δ_{xy} Δ_{xy} = …

Δ_y = *Transverse displacement demand*

δ_{yx} Δ_{yx} = …

δ_{yy} Δ_{yy} = …

λ = *Near-field effect factor*

μ_{max} = *Maximum strength ratio*

$\mu_{strength}$ = *Ratio of elastic strength demand to yield strength*

μ_Δ = …

ξ_{eff} or ξ = …

4.43. *3104F.7 References.*

[4.1] American Society of Civil Engineers (ASCE), 2010, ASCE/SEI 7-10 (ASCE/SEI 7), "Minimum Design Loads for Buildings and Other Structures," Reston, VA.

[4.2] American Society of Civil Engineers (ASCE), 2014, ASCE/COPRI 61-14 (ASCE/COPRI 61), "Seismic Design of Piers and Wharves," Reston, VA.

[4.3] American Society of Civil Engineers (ASCE), 2014, ASCE/SEI 41-13 (ASCE/SEI 41), "Seismic Evaluation and Retrofit of Existing Buildings," Reston, VA.

[4.41] Priestley, M.J.N., Seible Sieble, F., Calvi, G.M., 1996, "Seismic Design and Retrofit of Bridges," John Wiley & Sons, Inc., New York, USA.

[4.2] Applied Technology Council, ATC-40, 1996, "Seismic Evaluation and Retrofit of Concrete Buildings," Vol 1 and 2, Redwood City, CA.

[4.5] Kowalsky, M.J., Priestley, M.J.N, MacRae, G.A., 1994, "Displacement-Based Design – A Methodology for Seismic Design Applied to Single Degree of Freedom Reinforced Concrete Structures," Report No. SSRP – 94/16, University of California, San Diego.

[4.63] Federal Emergency Management Agency (FEMA) Applied Technology Council (ATC-55 Project), June 2005, FEMA 440, "FEMA 440 Improvement of Nonlinear Static Seismic Analysis Procedures," Redwood City, CA.

[4.74] Ferritto, J., Dickenson, S., Priestley N., Werner, S., Taylor, C., Burke, D., Seelig, W., and Kelly, S., 1999, "Seismic Criteria for California Marine Oil Terminals," Vol.1 and Vol.2, Technical Report TR-2103-SHR, Naval Facilities Engineering Service Center, Port Hueneme, CA.

[4.85] CalARP Program Seismic Guidance Committee, December 2013 September 2009, "Guidance for California Accidental Release Prevention (CalARP) Program Seismic Assessments," Sacramento, CA.

Authority: Sections 8750 through 8760 8755 and 8757, Public Resources Code.

Reference: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

Notation
Authority: Sections 8750 through 8760, Public Resources Code.
References: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

DIVISION 5
SECTION 3105F
MOORING AND BERTHING ANALYSIS AND DESIGN

5.1. ***3105F.1.5 Analysis and design of mooring components.*** *…*

The analysis and design of mooring components shall be based on the loading combinations and safety factors defined in Section 3103F.8 through 3103F.10, and in accordance with ACI 318 [5.1], AISC 325 [5.2] and ANSI/AWC ~~ANSI/AF&PA~~ NDS [5.3], as applicable.

5.2. ***3105F.2 Mooring analyses.*** *…*

Two procedures, manual and numerical are available for performing mooring analyses. These procedures shall conform to either the OCIMF (MEG 3) ~~document, "Mooring Equipment Guidelines (MEG3)"~~ [5.4] or UFC 4-159-03 ~~the Department of Defense "Moorings" document~~ [5.5]. …

…

The most severe combination of the environmental and operational conditions has to be identified for each mooring component. At a minimum, the following conditions shall be considered:

1. *…*
2. *…*
3. *…*
4. *…*
5. *The maximum allowable extension limits of the loading arms and/or hoses.*
6. *The maximum allowable compression/deflection of the fender system.*

5.3. ***3105F.2.1 Manual procedure.*** *Simplified calculations may be used to determine the mooring forces for barges with Favorable S~~s~~ite C~~c~~onditions (see Table 31F-3-8 ~~31F-3-10~~) and no passing vessel effects (see Section 3105F.3.2), except if any of the following conditions exist (Figures 31F-5-2 and 31F-5-3~~, below~~).*

…

5.4. ***3105F.3.4 Tsunami.*** *Run-up and current velocity shall be considered in the tsunami assessment. Section 3103F.5.7 and Table 31F-3-6 ~~31F-3-8~~ provides run-up values for the San Francisco Bay area, Los Angeles/Long Beach Harbors and Port Hueneme.*

5.5. ***3105F.4 Berthing analysis and design.*** *The analysis and design of berthing components shall be based on the loading combinations and safety factors defined in Section 3103F.8 through 3103F.9, and in accordance with ACI 318 [5.1], AISC 325 [5.2], and ANSI/AWC ~~ANSI/AF&PA~~ NDS [5.3], as applicable.*

5.6. ***3105F.4.3.1 Continuous fender system.*** *…*

…

The contact length, L_c , can be calculated using rational analysis considering curvature of the bow and berthing angle approximated by the chord formed by the curvature of the bow and the berthing angle as shown in Equation 5-2 below.

$$L_c = 2r \sin\alpha \qquad (5\text{-}2)$$

where:

L_c = contact length

r = Bow radius

α = Berthing angle

In lieu of detailed analysis to determine the contact length, Table 31F-5-1 may be used. The contact length for a vessel within the range listed in the table can be obtained by interpolation for a vessel within the range listed in the table can be obtained by interpolation.

5.7. ***3105F.4.5 Design and selection of new fender systems.*** *For guidelines on new fender designs, refer to the Department of Defense "Piers and Wharves" document (UFC 4-152-01) [5.8] and the PIANC Guidelines for the Design of Fenders Systems: 2002 [5.9]. Velocity and temperature factors, contact angle effects and manufacturing tolerances shall be considered (see Appendices A and B of PIANC [5.9]). Also, see Section 3103F.6.*

5.8. ***3105F.5 Layout of new MOTs.*** *The number and spacing of independent mooring dolphins and breasting dolphins depends on the DWT and length overall (LOA) of vessels to be accommodated.*

Breasting dolphins shall be positioned adjacent to the parallel body of the vessel when berthed. A minimum of two breasting dolphins shall be provided. The spacing of breasting dolphins shall be adequate for all sizes of vessels that may berth at the MOT.

Mooring dolphins shall be set back from the berthing line (fender line) for a distance between 115 ft and 165 ft, so that longer bow, stern and breast lines can be deployed.

For a preliminary layout, the guidelines in the British Standards, Part 4, Section 2 [5.10], may be used in conjunction with the guidelines below.

1. *If four breasting dolphins are provided, the spacing between exterior breasting dolphins shall be between 0.3 and 0.4 LOA of the maximum sized vessel expected to call at the MOT. The spacing between interior breasting dolphins shall be approximately 0.3 to 0.4LOA of the minimum sized vessel expected to call at the MOT.*
2. *If only two breasting dolphins are provided, the spacing between the dolphins shall be the smaller (0.3LOA) of the guidelines specified above.*
3. *If bow and stern lines are used for mooring, the spacing between exterior mooring dolphins shall be 1.35 times the LOA of the maximum sized vessel expected to call at the MOT.*
4. *The spacing between interior mooring dolphins shall be 0.8 times the LOA of the maximum sized vessel expected to call at the MOT.*

Guidelines for layout of new MOTs are provided in OCIMF MEG3 [5.4]. The final layout of the mooring and breasting dolphins shall be determined based on the results of the mooring analysis that provides optimal mooring line and breasting forces for the range of vessels to be accommodated. ~~The breasting force under the mooring condition shall not exceed the maximum fender reaction of the fender unit when it is being compressed at the manufacturers rated deflection.~~

5.9. ***3105F.6 Offshore moorings.*** *Offshore MOT moorings shall be designed and analyzed considering the site water depth, metocean environment and class of vessels calling per OCIMF MEG3 [5.4] or UFC 4-152-01 [5.8].*

5.10. ***3105F.6.1 Mooring analyses.*** *Analysis procedures shall conform to the OCIMF MEG3 [5.4] or UFC 4-159-03 [5.5], and the following:*

1. *A mooring analysis shall be performed for the range of tanker classes and barges calling at each offshore berth.*
2. *Forces acting on moored vessels shall be determined according to Section 3103F.5 and analysis shall consider all possible vessel movements, contribution of buoys, sinkers, catenaries affecting mooring line stiffness and anchorages.*
3. *Correlation of winds, waves and currents shall be considered. The correlation may be estimated by probabilistic analysis of metocean data.*
4. *The actual expected displacement of the vessels shall be used in the analysis.*
5. *Underwater inspections and bathymetry shall be considered.*
6. *Both fully laden and ballast conditions shall be considered.*
7. *Dynamic analysis shall be used to evaluate moorings performance.*

5.11. ***3105F.6.2 Design of mooring components.*** *Design of mooring components shall be based on loading combinations and safety factors defined in Sections 3103F.8 through 3103F.10 and follow the guidelines provided in either the OCIMF MEG3 [5.4] or UFC 4-159-03 [5.5].*

5.12. ***3105F.~~6~~7 Symbols.*** *…*

α	=	Horizontal mooring line angles~~Berthing angle. It also indicates the angle of horizontal mooring lines, see Fig 5-2.~~
Δ	=	…
θ	=	…
B	=	…
F	=	…
L	=	…
~~L_c~~	=	~~Contact length~~
N	=	…
~~r~~	=	~~Bow radius~~
μ	=	…
V	=	…
V_c	=	…
V_{crit}	=	…
~~V_w~~	=	~~Maximum wind speed (knots)~~

5.13. ***3105F.8~~7~~ References.***

[5.1] American Concrete Institute (ACI), 2014, ACI 318-14 (ACI 318)~~, ACI 318-05, 2005~~, "Building Code Requirements for Structural Concrete (ACI 318-14~~ 318-05~~) and Commentary (ACI 318R-14~~ 318R-05~~)," Farmington Hills, MI~~ Michigan~~.

[5.2] American Institute of Steel Construction, Inc. (AISC), 2011, AISC 325-11 (AISC 325)~~, 2005~~, "Steel Construction Manual," 14th ed.~~ Thirteenth Edition~~, Chicago, IL.

[5.3] American Wood Council (AWC), 2014, ANSI/AWC NDS-2015 (ANSI/AWC NDS)~~ American Forest & Paper Association, 2005~~, "National Design Specification (NDS) for Wood Construction,"~~ ANSI/ AF&PA NDS-2005,~~ Washington, D.C.

[5.4] Oil Companies International Marine Forum (OCIMF), 2008, "Mooring Equipment Guidelines (MEG3)," 3rd Ed., London, England.

[5.5] Department of Defense, 3 October 2005 (Revised 1 September 2012), Unified Facilities Criteria (UFC) 4-159-03, "Design: Moorings"~~, Unified Facilities Criteria (UFC) 4-152-03~~, Washington D.C.~~, USA~~.

[5.6] Department of Defense, 12 December 2001 (Revised 19 October 2010), Unified Facilities Criteria (UFC) 4-150-06, "Military Harbors and Coastal Facilities"~~, Unified Facilities Criteria (UFC) 4-150-06~~, Washington D.C.~~, USA.~~

[5.7] Kilner F.A., 1961, "Model Tests on the Motion of Moored Ships Placed on Long Waves." Proceedings of 7th Conference on Coastal Engineering, August 1960, The Hague, Netherlands, published by the Council on Wave Research - The Engineering Foundation.

[5.8] Department of Defense, 28 July 2005 (Revised 1 September 2012), Unified Facilities Criteria (UFC) 4-152-01, "Design: Piers and Wharves,"~~ Unified Facilities Criteria (UFC), 4-152-01~~, Washington D.C.~~, USA.~~

[5.9] Permanent International Association of Navigation Congresses (PIANC), 2002, "Guidelines for the Design of Fender Systems: 2002," Brussels.

~~[5.10] British Standards Institution, 1994, "British Standard Code of Practice for Maritime Structures – Part 4. Code of Practice for Design of Fendering and Mooring Systems," BS6349, London, England.~~

Authority: Sections 8750 through 8760~~ 8755 and 8757~~, Public Resources Code.

Reference: Sections 8750, 8751, 8755, and 8757, Public Resources Code.

Notation
Authority: Sections 8750 through 8760, Public Resources Code.
References: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

DIVISION 6
SECTION 3106F
GEOTECHNICAL HAZARDS AND FOUNDATIONS

6.1. ***3106F.1.1 Purpose.*** *This section provides minimum standards for analyses and evaluation of geotechnical hazards and foundations<u> under static and seismic conditions</u>.*

6.2. ***3106F.1.3 ~~Seismic l~~ <u>L</u>oading.*** *The ~~seismic~~ loading for geotechnical hazard assessment and foundation analyses<u> under static and seismic conditions</u> is provided in Section<u>s 3103F</u> ~~3103F.4~~<u> and 3104F</u>.*

6.3. ***3106F.2 Site characterization.*** *<u>Site characterization shall be based on site-specific geotechnical information. If existing information is used, the geotechnical engineer of record shall provide adequate justification.</u>*

6.4. ***3106F.2.1 Site classes.*** *Each MOT shall be assigned at least one site class~~, based on site-specific geotechnical information~~. Site Classes<u> A, B, C, D, and E</u> ~~S_A, S_B, S_C, S_D, and S_E~~ are defined in Table 31F-6-1~~,~~ and Site Class<u> F</u> ~~S_F~~ is defined<u> by any of the following</u> ~~as follows~~:*

1. *Soils vulnerable to significant potential loss of stiffness, strength, and/or volume under seismic loading<u> due to</u>~~, such as~~ liquefiable soils, quick and highly sensitive clays, and<u>/or</u> collapsible weakly cemented soils.*
2. *Peats and/or highly organic clays, where the thickness of peat or highly organic clay exceeds 10 feet.*
3. *Very high plasticity clays with a plasticity index (PI) greater than 75, where the<u> thickness</u> ~~depth~~ of clay exceeds 25 feet.*
4. *Very thick soft/medium stiff clays<u> with undrained shear strength less than 1,000 psf</u>, where the <u>thickness</u> ~~depth~~ of clay exceeds 120 feet.*

6.5. ***3106F.2.2. Site-specific information.*** *~~In general, geotechnical characterization shall be based on site-specific information. This information may be obtained from existing or new sources. However, if existing or nonsite specific information is used, the geotechnical engineer of record shall provide adequate justification for its use.~~*

<u>1.</u> *Site-specific investigations shall include<u> adequate</u>~~, at a minimum,~~ borings and/or cone penetration tests<u> (CPTs) and other appropriate field methods, to enable the determination of geotechnical parameters</u>~~, soil classifications, configuration, foundation loading and an assessment of seismic hazards. The array (number and depths) of exploratory borings and cone penetration tests (CPT) will depend on the proposed or existing structures and site stratigraphy. The investigation or testing activities shall be completed following the procedures in Section 5 of SCEC [6.3]. CPT data may also be used by first converting to standard penetration test (SPT) data, using an appropriate method, that reflects the effects of soil gradation. If geotechnical data other than SPT and CPT are used, an adequate explanation and rationale shall be provided.~~*

2. *Adequate coverage of subsurface data, both horizontally and vertically, shall be obtained to develop geotechnical parameters.*

3. *Exploration shall be deep enough to characterize subsurface materials that are affected by embankment behavior and shall extend to depth of at least 20 feet below the deepest foundation depth.*

4. *During field exploration, particular attention shall be given to the presence of continuous low-strength layers or thin soil layers that could liquefy or weaken during the design earthquake shaking.*

5. *CPTs provide continuous subsurface profile and shall be used to complement exploratory borings. When CPTs are performed, at least one boring shall be performed next to one of the CPT soundings to check that the CPT-soil behavior type interpretations are reasonable for the site. Any difference between CPT interpretation and subsurface condition obtained from borings shall be reconciled.*

6. *Quantitative site soil stratigraphy information is required to a depth of 100 feet below the mudline, for assigning a sSite cClass (see Table 31F-6-1). When data to a depth of 100 feet is unavailable, other information such as geologic considerations may be used to determine the Site Class.*

7. *Laboratory tests may be necessary to supplement the borings and insitu field tests.*

6.6.

TABLE 31F-6-1
SITE CLASSES

SITE CLASS	SOIL PROFILE NAME/GENERIC DESCRIPTION	AVERAGE VALUES FOR TOP 100 FEET OF SOIL PROFILE[3]		
		Shear Wave Velocity, V_S [ft/sec]	Standard Penetration Test, SPT [blows/ft]	Undrained Shear Strength, S_U [psf]
A S_A	Hard Rock	>5,000	-	-
B S_B	Rock	2,500 to 5,000	-	-
C S_C	Very Stiff/ Very Dense Soil and Soft Rock	1,200 to 2,500	>50	>2,000
D S_D	Stiff/Dense Soil Profile	600 to 1,200	15 to 50	1,000 to 2,000
E[1,2] S_E	Soft/Loose Soil Profile	<600	<15	<1,000
F S_F	Defined in Section 3106F.2.1			

Notes:

1. Site Class SF shall require site-specific geotechnical information as discussed in Sections 3106F.2.2 and 3103F.4.

12. Site Class E SE also includes any soil profile with more than 10 feet of soft clay (defined as a soil with a plasticity index, PI>20, water content >40 percent and S_U<500 psf).

23. The plasticity index, PI, and the moisture content shall be determined in accordance with ASTM D4318 [6.1] and ASTM D2216 [6.2], respectively.

3. Conversion of CPT data to estimate equivalent V_s, SPT blow count, or S_u is allowed.

6.7. ***3106F.3 Seismic loads for geotechnical evaluations.*** *Section 3103F.4 defines the earthquake loads to be used for structural and geotechnical evaluations in terms of design Peak Ground Accelerations (PGA), spectral accelerations and design earthquake magnitude. Values used for analyses are based on Probabilistic Seismic Hazard Analyses (PSHA) using two levels of seismic performance criteria (Section 3104F.2.1 and Table 31F-4-1).*

6.8. ***3106F.4~~3~~ Liquefaction potential.*** ~~*A liquefaction assessment shall address triggering and the resulting hazards, using residual shear strengths of liquefied soils.*~~ *The liquefaction potential of the soils in the immediate vicinity of or beneath each MOT, and associated slopes, embankments or rock dikes shall be evaluated for the PGAs associated with seismic performance Levels 1 and 2. Liquefaction potential evaluation should follow the procedures outlined in NCEER report [6.3], SCEC [6.4] and CGS Special Publication 117A [6.5].*

If liquefaction is shown to be initiated in the above evaluations, the particular liquefiable strata and their thicknesses shall be clearly shown on site profiles. Resulting hazards associated with liquefaction shall be addressed including translational or rotational deformations of slopes or embankment systems and post liquefaction settlement of slopes or embankment systems and underlying foundation soils, as noted below. If such analyses indicate the potential for partial or gross (flow) failure of a slope or embankment, adequate evaluations shall be performed to confirm such a condition exists, together with analyses to evaluate potential slope displacements (lateral spreads). In these situations and for projects where more detailed numerical analyses are performed, a peer review (see Section 3101F.8.2) may be required.

6.9. ~~***3106F.3.1 Triggering assessment.*** *Liquefaction triggering shall be expressed in terms of the factor of safety (SF):*~~

~~*SF = CRR/CSR*~~ ~~*(6-1)*~~

~~***where:***~~

~~*CRR = Cyclic Resistance Ratio*~~

~~*CSR = The Cyclic Stress Ratio induced by Design Peak Ground Acceleration (DPGA) or other postulated shaking*~~

~~*The CRR shall be determined from Figure 7.1 in SCEC [6.3]. If available, both the SPT and CPT data can be used.*~~

~~*CSR shall be evaluated using the simplified procedure in Section 3106F.3.1.1 or site-specific response analysis procedures in Section 3106F.3.1.2.*~~

~~*Shaking-induced shear strength reductions in liquefiable materials are determined as follows:*~~

~~*1. SF > 1.4*~~

~~*Reductions of shear strength for the materials for post-earthquake conditions may be neglected.*~~

~~*2. 1.0 < SF < 1.4*~~

~~*A strength value intermediate to the material's initial strength and residual undrained shear strength should be selected based on the level of residual excess pore water pressure expected to be generated by the ground shaking (e.g., Figure 10 of Seed and Harder, [6.4]).*~~

~~*3. SF ≤ 1.0*~~

~~*Reduction of the material shear strength to a residual undrained shear strength level shall be considered, as described in Section 3106F.3.2.*~~

~~***3106F.3.1.1 Simplified procedure.*** *The simplified procedure to evaluate liquefaction triggering shall follow Section 7 of SCEC [6.3]. Cyclic stress ratio (CSR) is used to define seismic loading, in terms of the Design Peak Ground Acceleration (DPGA) and Design Earthquake Magnitude (DEM). DPGA and DEM are addressed in Section 3103F.4.2. CSR is defined as:*~~

$$CSR = 0.65\left(\frac{DPGA}{g}\right)\left(\frac{\sigma_v}{\sigma_v'}\right)\left(\frac{r_d}{r_{MSF}}\right) \qquad (6\text{-}2)$$

~~***where:***~~

~~*g = gravitational constant*~~

~~σ_v = *the vertical total stress*~~

~~σ'_v = *the vertical effective stress*~~

~~r_d = *a stress reduction factor*~~

~~r_{MSF} = *the magnitude scaling factor*~~

~~*For values of* r_{MSF} *and* r_d*, see SCEC [6.3] Figures 7.2 and 7.3, respectively. To evaluate* r_{MSF}*, the DEM value associated with DPGA shall be used.*~~

~~***3106F.3.1.2 Site specific response procedure.*** *In lieu of the simplified procedure, either one-dimensional or two-dimensional site response analysis may be performed using the ground motion parameters discussed in subsection 3103F.4. The computed cyclic stresses at various points within the pertinent soil layers shall be expressed as values of CSR.*~~

~~***3106F.3.2 Residual strength.*** *The residual undrained shear strength may be estimated from Figure 7.7 of SCEC [6.3]. When necessary, a conservative extrapolation of the range should be made. Under no circumstances, shall the residual shear strength be higher than the shear strength based on effective strength parameters.*~~

~~*The best estimate value should correspond to 1/3 from the lower bound of the range for a given value of equivalent clean sand SPT blowcount. When a value other than the "1/3 value" is selected for the residual shear strength, the selection shall be justified. An alternate method is provided in Stark and Mesri [6.5]. The residual strength of liquefied soils may be obtained as a function of effective confining pressures if a justification is provided. The resulting residual shear strength shall be used as the post-earthquake shear strength of liquefied soils.*~~

6.10. ~~***3106F.4 Other geotechnical hazards.*** *For a SF less than 1.4, the potential for the following hazards shall be evaluated:*~~

~~*1. Flow slides*~~

~~*2. Slope movements*~~

~~*3. Lateral Spreading*~~

~~*4. Ground settlement and differential settlement*~~

5. Other surface manifestations

These hazards shall be evaluated, using the residual shear strength described above (Section 3106F.3.2).

3106F.4.1 Stability of earth structures. *If a slope failure could affect the MOT, a stability analysis of slopes and earth retaining structures shall be performed. The analysis shall use limit equilibrium methods that satisfy all of the force and/or moment equilibrium conditions and determine the slope stability safety factor.*

1. Slope stability safety factor ≥ 1.2

Flow slides can be precluded; however, seismically induced ground movements shall be addressed.

2. 1.0 ≤ Slope stability safety factor < 1.2

Seismically induced ground movements should be evaluated using the methods described below.

3. Slope stability safety factor < 1.0

Mitigation measures shall be implemented per Section 3106F.6.

3106F.4.2 Simplified ground movement analysis. *The seismically induced ground settlement may be estimated using Section 7.6 of SCEC [6.3]. Surface manifestation of liquefaction may be evaluated using Section 7.7 of SCEC. Results shall be evaluated to determine if mitigation measures are required.*

Seismically induced deformation or displacement of slopes shall be evaluated using the Makdisi-Seed [6.6] simplified method as described below.

The stability analysis shall be used with the residual shear strengths of soils to estimate the yield acceleration coefficient, K_y, associated with the critical potential movement plane. In general, the DPGA shall be used as K_{max} (see [6.6]) and DEM as the earthquake magnitude, M. These parameters shall be used together with the upper bound curves Figures 9–11 of [6.6], to estimate the seismically induced ground movement along the critical plane.

However, the value of K_{max} may be different from the DPGA value to include the effects of amplification, incoherence, etc. When such adjustments are made in converting DPGA to K_{max}, a justification shall be provided. Linear interpolation using the upper bound curves in Figure 10 in [6.6] or Figure 4-10 in Ferritto et al [6.7] can be used to estimate the seismically induced ground movement for other earthquake magnitudes.

For screening purposes only, lateral spreading shall be evaluated, using the simplified equations in Youd et al. [6.8]. The total seismically induced ground displacement shall include all contributory directions.

1. *When the resulting displacement from the screening method is > 0.1 ft., the Makdisi-Seed simplified method or other similar methods shall be used to estimate lateral spreading.*
2. *If the computed displacement from the simplified method(s) is ≤ 0.5 ft., the effects can be neglected.*
3. *If the computed displacements using simplified methods are > 0.5 ft., the use of a detailed ground movement analysis (see Section 6.4.3) may be considered.*
4. *If the final resulting displacement, regardless of the method used, remains > 0.5 ft., it shall be considered in the structural analysis.*

~~***3106F.4.3 Detailed ground movement analysis.*** *As an alternative to the simplified methods discussed above, a two-dimensional (2-D) equivalent linear or nonlinear dynamic analysis of the MOT and/or slopes and earth retaining systems may be performed.*~~

~~*An equivalent linear analysis is adequate when the stiffness and/or strength of the soils involved are likely to degrade by less than one-third, during seismic excitation of less than 0.5 g's. Appropriate time histories need to be obtained to calculate seismically induced displacement (see Section 3103F.4.2). Such analysis should account for the accumulating effects of displacement if double-integration of acceleration time histories is used. The seismic stresses or stress time histories from equivalent linear analysis may be used to estimate seismically induced deformation.*~~

~~*A nonlinear analysis should be used if the stiffness and/or strength of the soils involved are likely to degrade by more than one-third during seismic motion.*~~

~~*If the structure is included in the analysis, the ground motion directly affects the structural response. Otherwise, the uncoupled, calculated movement of the soil on the structure shall be evaluated.*~~

6.11. ***3106F.5 Slope or embankment stability and seismically induced lateral spreading.*** *Slope or embankment stability related to the MOT facility, shall be evaluated for static and seismic loading conditions.*

6.12. ***3106F.5.1 Static slope stability.*** *Static stability analysis using conventional limit equilibrium methods shall be performed for site related slope or embankment systems. Live load surcharge shall be considered in analyses based on project-specific information. The long-term static factor of safety of the slope or embankment shall not be less than 1.5.*

6.13. ***3106F.5.2 Pseudo-static seismic slope stability.*** *Pseudo-static seismic slope or embankment stability analyses shall be performed to estimate the horizontal yield acceleration for the slope for the Level 1 and Level 2 earthquakes. During the seismic event, appropriate live load surcharge shall be considered.*

If liquefaction and/or strength loss of the site soils is likely, the following shall be used in the analyses, as appropriate:

1. *Residual strength of liquefied soils*
2. *Strengths compatible with the pore-pressure generation of potentially liquefiable soils*
3. *Potential strength reduction of clays*

The residual strength of liquefied soils shall be estimated using guidelines outlined in SCEC [6.4] or other appropriate documents as noted in CGS Special Publication 117A [6.5].

Pseudo-static analysis shall be performed without considering the presence of the foundation system. Using a horizontal seismic coefficient of one-half of the PGA, if the estimated factor of safety is greater than or equal to 1.1, then no further evaluation of lateral spreading or kinematic loading from lateral spreading is required.

6.14. ***3106F.5.3 Post-Earthquake static slope stability.*** *The static factor of safety immediately following a design earthquake event shall not be less than 1.1 when any of the following are used in static stability analysis:*

1. Post-earthquake residual strength of liquefied soils

2. Strengths compatible with the pore-pressure generation of potentially liquefiable soils

3. Potential strength reduction of clays

6.15. ***3106F.5.4 Lateral spreading – Free field.*** *The earthquake–induced lateral deformations of the slope or embankment and associated foundations soils shall be determined for the Level 1 and Level 2 earthquakes using the associated PGA at the ground surface (not modified for liquefaction). If liquefaction and/or strength loss of the site soils is likely, the following shall be used in the analyses, as appropriate:*

1. Residual strength of liquefied soils

2. Strengths compatible with the pore-pressure generation of potentially liquefiable soils

3. Potential strength reduction of clays

The presence of the foundation system shall not be included in the “free field” evaluations.

Initial lateral spread estimates shall be made using the Newmark displacement approach documented in NCHRP Report 611 [6.6] or other appropriate but similar procedures.

6.16. ***3106F.6 Seismically induced settlement.*** *Seismically induced settlement shall be evaluated. Based on guidelines outlined in SCEC [6.4] or other appropriate documents such as CGS Special Publication 117A [6.5]. If seismically induced settlement is anticipated, the resulting design impacts shall be considered, including the potential development of downdrag loads on piles.*

6.17. ***3106F.7 Earth pressures.*** *Both static and seismic earth pressures acting on MOT structures shall be evaluated.*

6.18. ***3106F.7.1 Earth pressures under static loading.*** *The effect of static active earth pressures on structures resulting from static loading of backfill soils shall be considered where appropriate. Backfill sloping configuration, if applicable, and backland loading conditions shall be considered in the evaluations. The loading considerations shall be based on project-specific information. The earth pressures under static loading should be based on guidelines outlined in NAVFAC DM7-02 [6.7] or other appropriate documents.*

6.19. ***3106F.7.2 Earth pressures under seismic loading.*** *The effect of earth pressures on structures resulting from seismic loading of backfill soils, including the effect of pore-water pressure build-up in the backfill, shall be considered. The seismic coefficients used for this analysis shall be based on the Level 1 and Level 2 earthquake PGA values.*

Evaluation of earth pressures under seismic loading, should be based on NCHRP Report 611 [6.6] or other appropriate methods.

6.20. ***3106F.8 Pile axial behavior.***

6.21. ***3106F.8.1 Axial pile capacity.*** *Axial geotechnical capacity of piles under static loading shall be evaluated using guidelines for estimating axial pile capacities provided in POLB WDC [6.8] or other appropriate documents. A minimum factor of safety of 2.0 shall be achieved on the ultimate capacity of the pile using appropriate MOT loading.*

If liquefaction or seismically-induced settlement is anticipated, the ultimate axial geotechnical capacity of piles under seismic conditions shall be evaluated for the effects of liquefaction and/or downdrag forces on the pile. The ultimate geotechnical capacity of the pile during liquefaction shall be determined on the basis of the residual strength of the soil for those layers where the factor of safety for liquefaction is determined to be less than 1.0.

When seismically-induced settlements are predicted to occur during design earthquakes, the downdrag loads shall be computed, and the combination of downdrag load and static load determined. Only the tip resistance of the pile and the side friction resistance below the lowest layer contributing to the downdrag shall be used in the capacity evaluation. The ultimate axial geotechnical capacity of the pile shall not be less than the combination of the seismically induced downdrag force and the maximum static load.

6.22. ***3106F.8.2 Axial springs for piles.*** *The geotechnical analyst (see Section 3102F.3.4.8) shall coordinate with the structural analyst (see Section 3102F.3.4.4) and develop axial springs (T-z) for piles. The T-z springs may be developed either at the top or at the tip of the pile (see Figure 31F-6-1). If the springs are developed at the pile tip, the tip shall include both the friction resistance along the pile (i.e., side springs [t-z]) and tip resistance at the pile tip (i.e. tip springs [q-w]), as illustrated in Figure 31F-6-1. If T-z springs are developed at the pile top, the appropriate elastic shortening of the pile shall be included in the springs. Linear or nonlinear springs may be developed if requested by the structural analyst.*

Due to the uncertainties associated with the development of axial springs, such as the axial soil capacities, load distributions along the piles and simplified spring stiffnesses, both upper-bound and lower-bound limits shall be estimated and utilized in the analyses.

6.23. Add new Figure 31F-6-1 :

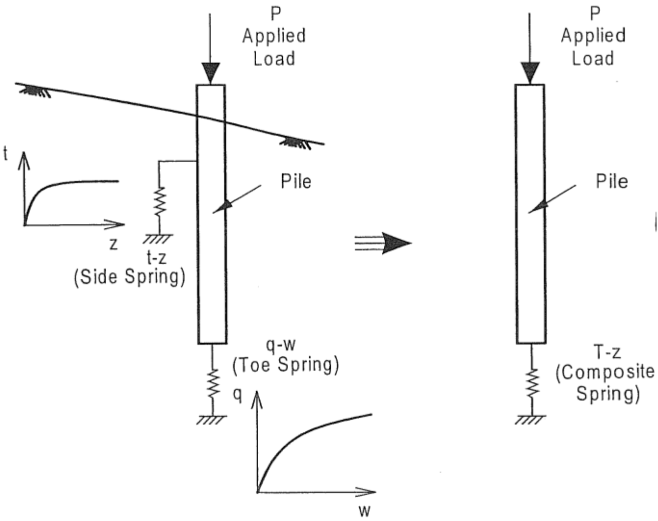


FIGURE 31F-6-1
AXIAL SOIL SPRINGS [6.8]

6.24. ***3106F.9 Soil springs for lateral pile loading.*** *For design of piles under loading associated with the inertial response of the superstructure, level-ground inelastic lateral springs (p-y) shall be developed. The lateral springs within the shallow portion of the piles (generally within 10 pile diameters below the ground surface) tend to dominate the inertial behavior. Geotechnical parameters for developing lateral soil springs shall follow guidelines provided in API RP 2A-WSD [6.9] or other appropriate documents.*

Due to uncertainties associated with the development of p-y curves for dike structures, upper-bound and lower-bound p-y springs shall be developed for use in superstructure inertial response analyses.

6.25. ***3106F.10~~5~~ Soil-pile ~~structure~~ interaction.*** *Two separate loading conditions for the piles shall be considered:*

1. ~~(1)~~ Inertial loading under seismic conditions~~, and~~

2. ~~(2)~~ Kinematic loading from lateral ground spreading~~.~~

Inertial loading is associated with earthquake-induced lateral loading on a structure, while kinematic loading refers to loading on foundation piles from earthquake induced lateral deformations of the slope/embankment/dike system. Simultaneous application of these loading conditions shall be evaluated with due consideration of the phasing and locations of these loads on foundation elements. The foundation ~~design~~ shall be designed such that ~~meet~~ the structural performance ~~requirements of this Code,~~ is acceptable when subjected to both inertial and kinematic loadings.

6.26. ~~***3106F.5.1 Soil parameters.*** *Soil structure interaction (SSI) shall be addressed for the seismic evaluation of MOT structures. SSI may consist of linear or non-linear springs (and possibly dash-pots) for various degrees of freedom, including horizontal, vertical, torsional, and rotational, as required by the structural analysis.*~~

~~*Pile capacity parameters may be evaluated using the procedures in Chapter 4 of FEMA 356 [6.9]. The "p-y" curves, "t-z" curves, and tip load – displacement curves for piles (nonlinear springs for horizontal and vertical modes and nonlinear vertical springs for the pile tip, respectively) and deep foundations shall be evaluated using Section 6 of API RP 2A-LRFD [6.10] including the consideration of pile group effects. Equivalent springs (and dashpots) representing the degrading properties of soils may be developed.*~~

~~*Where appropriate, alternative procedures can be used to develop these parameters. Rationale for the use of alternative procedures shall be provided. One simplified method is presented in Chapter 4 of the UFC 3-220-01A [6.11] and provides deflection and moment for an isolated pile, subject to a lateral load.*~~

6.27. ***3106F.10.1 Inertial loading under seismic conditions.*** *The lateral soil springs shall be used in inertial loading response analyses. The evaluation of inertial loading can be performed by ignoring potential slope/embankment/dike system deformations (i.e., one end of the lateral soil spring at a given depth is attached to the corresponding pile node and the other end is assumed fixed).*

6.28. ***3106F.10.2 Kinematic loading from lateral spreading.*** *Kinematic pile loading from permanent lateral spread ground deformation in deep seated levels of slope/embankment/dike foundation soils shall be evaluated. The lateral deformations shall be restricted such that the structural performance of foundation piles is not compromised.*

The lateral deformation of the embankment or dike and associated piles and foundation soils shall be determined using analytical methods as follows:

1. *Initial estimates of free field lateral spread deformations (in the absence of piles) may be determined using the simplified Newmark sliding block method as described in Section 3106F.5.4. The geotechnical analyst shall provide the structural analyst with level-ground p-y curves for the weak soil layer controlling the lateral spread and soil layers above and below the weak layer. Appropriate overburden pressures shall be used in simplified pushover analyses, to estimate the pile displacement capacities and corresponding pile shear within the weak soil zone.*
2. *For the pushover analysis, the estimated displacements may be uniformly distributed within the thickness of the weak soil layer (i.e., zero at and below the bottom of the layer to the maximum value at and above the top of the weak layer), or as appropriate.*
3. *For a simplified analysis (see Figure 31F-6-2), the pile shall be fixed against rotation and translation relative to the soil displacement at some distance above and below the weak soil layer. Between these two points, lateral soil springs are provided, which allow deformation of the pile relative to the deformed soil profile.*
4. *The geotechnical analyst shall perform pseudo-static slope stability analysis (Section 3106F.5.2) with the "pinning" effects of piles arising from pile shear in the weak zone incorporated, and estimate the displacement demands using simplified Newmark analysis. If the estimated displacement demands are less than the displacement capacities, as defined by the structural analyst, no further analysis for kinematic loading will be necessary.*

5. *If more detailed numerical analyses are deemed necessary to provide input to the structural analyst, two-dimensional dynamic soil-structure interaction analysis of the structure-pile-dike-soil system using numerical finite element or finite difference analyses shall be performed.*
6. *Sensitivity analyses shall also be performed on factors affecting the results.*
7. *As a minimum, deformation profiles along the length of the various pile row should be provided to the structural analyst to estimate strains and stresses in the piles for the purpose of checking performance criteria. Such analyses should be coordinated with the structural analyst.*

6.29. Add new Figure 31F-6-2 :

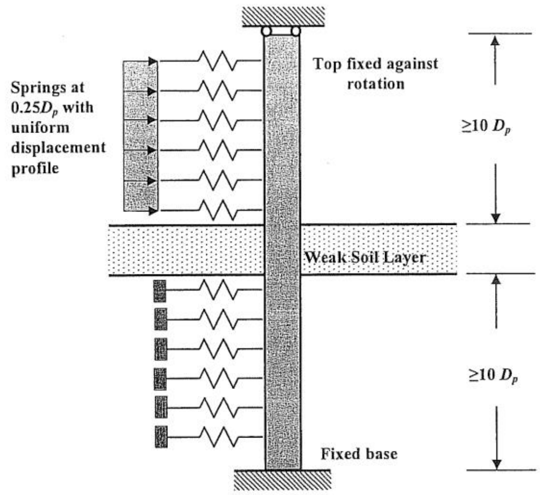


FIGURE 31F-6-2
SLIDING LAYER MODEL [6.8]

6.30. ***3106F.11 Soil-structure interaction – Shallow foundations and underground structures.***

6.31. ***3106F.11.1~~5.2~~ Shallow foundations.*** *Shallow foundations shall be assumed to move with the ground. Springs and dashpots may be evaluated as per Gazetas [6.10]~~[6.12]~~.*

6.32. ***3106F.11.2~~5.3~~ Underground structures.*** *Buried flexible structures or buried portions of flexible structures including piles and pipelines shall be assumed to deform with estimated ground movement at depth.*

As the soil settles, it shall be assumed to apply shear forces to buried structures or buried portions of structures including deep foundations.

6.33. ***3106F.12 Underwater seafloor pipelines.*** *Geotechnical evaluations of underwater pipelines shall include static stability of the seafloor ground supporting the pipeline and settlement and lateral deformation of the ground under earthquakes. If the pipeline is buried, the potential for uplift of the pipeline under earthquakes shall also be evaluated.*

6.34. ~~***3106F.6 Mitigation measures and alternatives.*** *If the hazards and consequences addressed in Sections 3106F.3 and 3106F.4 are beyond the specified range, the following options shall be considered:*~~

~~*1. Perform a more sophisticated analysis*~~

~~*2. Modify the structure*~~

~~*3. Modify the foundation soil*~~

~~*Examples of possible measures to modify foundation soils are provided in Table 4-1 of [6.7].*~~

6.35. ***3106F.13~~7~~ Symbols.***

A	=	*Site Class A as defined in Table 31F-6-1*
B	=	*Site Class B as defined in Table 31F-6-1*
C	=	*Site Class C as defined in Table 31F-6-1*
CPT	=	*Cone Penetration Test*
D	=	*Site Class D as defined in Table 31F-6-1*
D_p	=	*Pile diameter*
E	=	*Site Class E as defined in Table 31F-6-1*
F	=	*Site Class F as defined in Table 31F-6-1*
P	=	*Applied load*
PI	=	*Plasticity index*
p-y	=	*Lateral soil spring*
S_U	=	*Undrained shear strength*
SPT	=	*Standard Penetration Test*
t-z	=	*Axial soil spring along the side of pile*
T-z	=	*Composite axial soil spring at pile tip*
q-w	=	*Axial soil spring at pile tip*
V_S	=	*Shear wave velocity*
~~*SF*~~	=	~~*Safety Factor*~~
~~*CRR*~~	=	~~*Cyclic Resistance Ratio*~~
~~*CSR*~~	=	~~*Cyclic Stress Ratio induced by DPGA*~~
~~*g*~~	=	~~*Gravitational constant*~~
~~σ_v~~	=	~~*the vertical total stress*~~
~~σ'_v~~	=	~~*the vertical effective stress*~~
~~r_d~~	=	~~*a stress reduction factor*~~
~~r_{MSF}~~	=	~~*the magnitude scaling factor*~~

6.36. *3106F.148 References.*

[6.1] American Society for Testing and Materials (ASTM), 2014 2002, ASTM D4318-10 (ASTM D4318), "D4318-00 Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils," West Conshohocken, PA.

[6.2] American Society for Testing and Materials (ASTM), 2014 2002, ASTM D2216-10 (ASTM D2216), "D2216-98 Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass," West Conshohocken, PA.

[6.3] Youd, T.L., Idriss, I.M., Andrus, R.D., Arango, I., Castro, G. Christian, J.T., Dobry, R., Finn, W.D.L., Harder, L.F. Jr., Hynes, M.E., Ishihara, K., Koester, J.P., Liao, S.S.C., Marcuson, W.F., III, Martin, G.R., Mitchell, J.K., Moriwaki, Y., Power, M.S., Robertson, P.K., Seed, R.B., and Stokoe, K.H., II, 2001, "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils," Journal of Geotechnical and Geoenvironmental Engineering, ASCE, Volume 127, No. 10, p. 817-833.

[6.43] Southern California Earthquake Center (SCEC), March 1999, "Recommended Procedures for Implementation of DMG Special Publication 117, Guidelines for Analyzing and Mitigating Liquefaction in California," University of Southern California, Los Angeles.

[6.4] Seed, R.B. and Harder, C.F., 1999, SPT-Based Analysis of Cyclic Pore Pressure Generation and Undrained Residual Strength, Proceedings of the H.B. Seed Memorial Symposium, Editor: J.M. Duncan, BiTech Publishers Ltd., v. 2, pp. 351-376.

[6.5] Stark, T.D., and Mesri, G., 1992, Undrained shear strength of liquefied sands for stability analysis, Journal of Geotechnical Engineering, American Society of Civil Engineers, v118, n11, pp 1727-1747.

[6.6] Makdisi, F.I. and Seed, H.B., "Simplified Procedure for Estimating Dam and Embankment Earthquake-Induced Deformations", ASCE Journal of the Geotechnical Engineering Division, Vol 104, No. 7, pp. 849-867.

[6.7] Ferritto, J., Dickenson, S., Priestley N., Werner, S., Taylor, C., Burke D., Seelig W., and Kelly, S., 1999, "Seismic Criteria for California Marine Oil Terminals," Vol.1 and Vol.2, Technical Report TR-2103-SHR, Naval Facilities Engineering Service Center, Port Hueneme, CA.

[6.8] Youd, T. L., Hansen, C. M., and Bartlett, S. F., "Revised MLR Equations for Predicting Lateral Spread Displacement" Proceedings of the 7th U.S.-Japan Workshop on Earthquake Resistant Design of Lifeline Facilities and Countermeasures Against Soil Liquefaction, 1999."

[6.9] Federal Emergency Management Agency, FEMA-356, Nov. 2000, "Prestandard and Commentary for the Seismic Rehabilitation of Buildings," Washington, D.C.

[6.5] California Department of Conservation, California Geological Survey (CGS), 11 September 2008, "Guidelines for Evaluating and Mitigating Seismic Hazards in California," Special Publication 117A, Revised Release.

[6.6] National Cooperative Highway Research Program (NCHRP), 2008, "NCHRP Report 611: Seismic Analysis and Design of Retaining Walls, Buried Structures, Slopes, and Embankments,", Washington, D.C.

[6.7] Naval Facilities Engineering Command (NAVFAC), 1986, NAVFAC DM7-02, "Foundation and Earth Structures," Alexandria, VA.

[6.8] Port of Long Beach (POLB), 2012 February 29, "Wharf Design Criteria (WDC)," Version 3.0, Long Beach, CA.

[6.9~~10~~] American Petroleum Institute (API), November 2014~~ December 2000~~, API Recommended Practice 2A-WSD (API RP 2A-WSD), "Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms – Working Stress Design," 22nd ed., Washington, D.C.

~~[6.11] Department of Defense, 16 January 2004, Unified Facilities Criteria (UFC) 3-220-01A, "Deep Foundations," Washington, D.C.~~

[6.10~~12~~] Gazetas, G., September 1991, "Formulas and Charts for Impedances of Surface and Embedded Foundations," Journal of Geotechnical Engineering, ASCE, Vol. 117, No. 9~~, September, 1991~~.

Authority: Sections 8750 through 8760~~ 8755 and 8757~~, Public Resources Code.

Reference: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

Notation
Authority: Sections 8750 through 8760, Public Resources Code.
References: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

DIVISION 7
SECTION 3107F
STRUCTURAL ANALYSIS AND DESIGN OF COMPONENTS

7.1. ***3107F.2.5.3 Plastic hinge length.*** *…*

The pile's plastic hinge length, L_p (above ground) for reinforced concrete piles, when the plastic hinge forms against a supporting member is:

$$L_p = 0.08L + 0.15\, f_{ye} d_b \geq 0.3 f_{ye} d_b \quad (7\text{-}5)$$

$$L_p = 0.08L + 0.15\, f_{ye} d_{bl} \geq 0.3 f_{ye} d_b \quad (7\text{-}5)$$

where:

L = the distance from the critical section of the plastic hinge to the point of contraflexure

d_b d_{bl} = the diameter of the longitudinal reinforcement or dowel, whichever is used to develop the connection

f_{ye} = design yield strength of longitudinal reinforcement or dowel, whichever is used to develop the connection (ksi)

If a large reduction in moment capacity occurs due to spalling, then the plastic hinge length shall be:

$$L_p = 0.3 f_{ye} d_b \quad (7\text{-}6)$$

$$L_p = 0.3 f_{ye} d_{bl} \quad (7\text{-}6)$$

The plastic hinge length, L_p (above ground), for prestressed concrete piles may also be computed from Table 31F-7-4 for permitted pile-to-deck connections as described in ASCE/COPRI 61 [7.5].

When the plastic hinge forms in-ground, the plastic hinge length may be determined using Equation (7-7) [7.5]: from Figure 31F-7-4 (see page 311 of [7.1]).

$$L_p = 2D \quad (7\text{-}7)$$

where:

D = pile diameter or least cross-sectional dimension

The stiffness parameter (x-axis) is:

$$\frac{KD^6}{[D^*]EI_e} \quad (7\text{-}7)$$

where:

EI_e = the effective stiffness

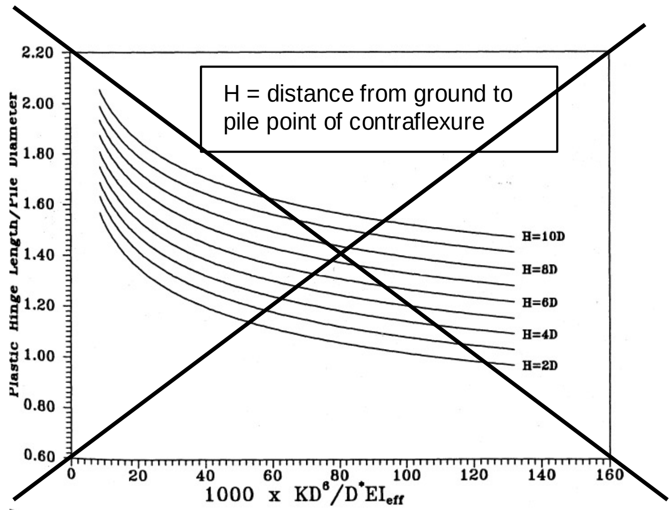
K = the subgrade modulus

D = pile diameter

D = reference diameter of 6 ft*

If site specific soil information is not available then the values for K in Table 31F-7-4 may be used.

7.2. Remove entirely:



~~FIGURE 31F-7-4~~
~~INFLUENCE OF PILE/SOIL STIFFNESS RATIO ON PLASTIC HINGE LENGTH (after Fig 5.30 of [7.1])~~

7.3. Remove entirely:

~~TABLE 31F-7-4~~
~~SUBGRADE MODULUS K~~

~~SOIL TYPE~~	***~~AVG UNDRAINED SHEAR STRENGTH [psf]~~***	***~~SUBGRADE MODULUS K [lb/in3]~~***
~~Soft Clay~~	*~~250-500~~*	*~~30~~*
~~Medium Clay~~	*~~500-1000~~*	*~~100~~*
~~Stiff Clay~~	*~~1000-2000~~*	*~~500~~*
~~Very Stiff Clay~~	*~~2000-4000~~*	*~~1000~~*
~~Hard Clay~~	*~~4000-8000~~*	*~~2000~~*
~~Loose Sand (above WT/submerged)~~	*~~-~~*	*~~25/20~~*
~~Medium Sand (above WT/submerged)~~	*~~-~~*	*~~90/60~~*
~~Dense Sand (above WT/submerged)~~	*~~-~~*	*~~275/125~~*

7.4. Add new Table 31F-7-4:

TABLE 31F-7-4

PLASTIC HINGE LENGTH FOR PRESTRESSED CONCRETE PILES [7.5]

CONNECTION TYPE	***L_p AT DECK (in.)***
Pile Buildup	$0.15 f_{ye} d_b \leq L_p \leq 0.30 f_{ye} d_b$
Extended Strand	$0.20 f_{pye} d_{st}$
Embedded Pile	*0.5D*
Dowelled	$0.25 f_{ye} d_b$
Hollow Dowelled	$0.20 f_{ye} d_b$
External Confinement	$0.30 f_{ye} d_b$
Isolated Interface	$0.25 f_{ye} d_b$

d_b = diameter of the prestressing strand or dowel, whichever is used to develop the connection (in.)

f_{ye} = design yield strength of prestressing strand or dowel, as appropriate (ksi)

D = pile diameter or least cross-sectional dimension

d_{st} = diameter of the prestressing strand (in.)

f_{pye} = design yield strength of prestressing strand (ksi)

7.5. ***3107F.2.5.4 Plastic rotation***. ~~*The plastic rotation, θ_p, can be determined from Equation 7-8, by using moment-curvature analysis and applicable strain limitations, as shown in Figure 31F-7-5.*~~

The plastic rotation is:

…

$$\phi_m = \frac{\varepsilon_{cm}}{c_u} \quad \text{(7-9)}$$

~~$$\phi_m = \frac{\varepsilon_{cm}}{C_u} \quad \text{(7-9)}$$~~

where:

ε_{cm} = *maximum limiting compression strain for the prescribed performance level (Table 31F-7-5)*

c_u = *neutral-axis depth, at ultimate strength of section*

Either Method A or B may be used for idealization of the moment-curvature curve.

~~*The yield curvature, ϕ_y is the curvature at the intersection of the secant stiffness, EI_e, through first yield and the nominal strength, (ε_c = 0.004)*~~

$$\phi_y = \frac{M_y}{EI_c} \qquad (7\text{-}10)$$

7.6. ***3107F.2.5.4.1 Method A.*** *For Method A, the yield curvature, ϕ_y is the curvature at the intersection of the secant stiffness, EI_c , through first yield and the nominal strength, (ε_c = 0.004).*

$$\phi_y = \frac{M_y}{EI_c} \qquad (7\text{-}10)$$

7.7.

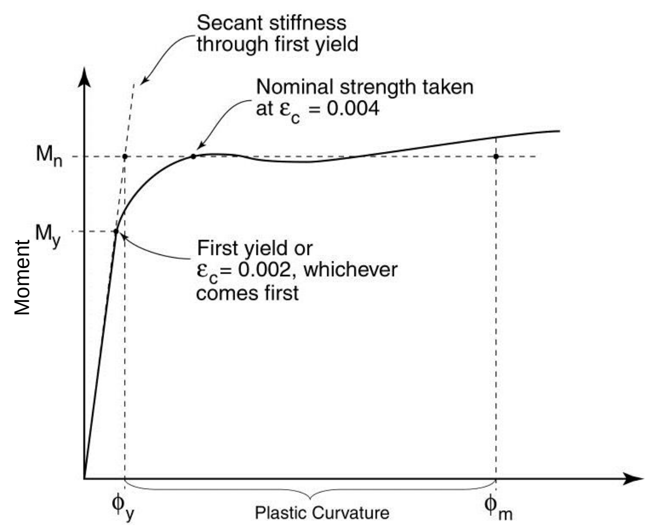


FIGURE 31F-7-4 31F-7-5
METHOD A – MOMENT CURVATURE ANALYSIS

7.8. ***3107F.2.5.4.2 Method B.*** *For Method B, the elastic portion of the idealized moment-curvature curve is the same as in Method A (see Section 3107F.2.5.4.1). However, the idealized plastic moment capacity, M_p , and the yield curvature ϕ_y , is obtained by balancing the areas between the actual and the idealized moment-curvature curves beyond the first yield point (see Figure 31F-7-5). Method B applies to moment-curvature curves that do not experience reduction in section moment capacity.*

7.9. Add new Figure 31F-7-5:

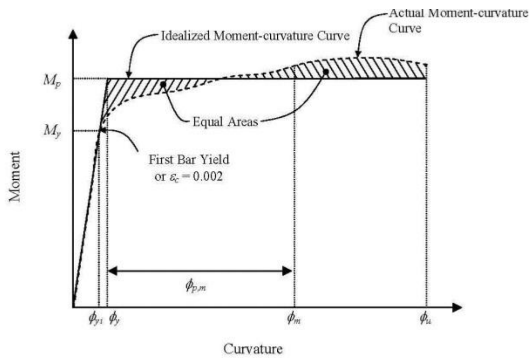


FIGURE 31F-7-5
METHOD B – MOMENT CURVATURE ANALYSIS [7.6]

7.10. ***3107F.2.5.6 Component acceptance/damage criteria.*** *…*

For all non-seismic loading combinations, concrete components shall be designed in accordance with the ACI 318 [7.7] requirements ~~[7.5]~~.

Note that for existing facilities, the pile/deck hinge may be controlled by the capacity of the dowel reinforcement in accordance with Section 3107F.2.7 ~~317F.2. 7~~.

7.11. ***3107F.2.5.7 Shear design.*** *If expected lower bound of material strength Section 3107F.2.1.1 Equations (7-2a, 7-2b, 7-2c) are used in obtaining the nominal shear strength, a new nonlinear analysis utilizing the upper bound estimate of material strength Section 3107F.2.1.1 Equations (7-3a, 7-3b, 7-3c) shall be used to obtain the plastic hinge shear demand. An alternative conservative approach is to multiply the maximum shear demand, V_{max}, from the original analysis by 1.4 (Section 8.16.4.4.2 of ATC-32 [7.8]~~[7.6]~~):*

…

Shear capacity shall be based on nominal material strengths, and reduction factors according to ACI 318 [7.7] ~~ACI-318 [7.5]~~.

As an alternative, the method of Kowalski and Priestley [7.9]~~[7.7]~~ may be used. Their method is based on a three-parameter model with separate contributions to shear strength from concrete (V_c), transverse reinforcement (V_s), and axial load (V_p) to obtain nominal shear strength (V_n):

…

$$V_c = k\sqrt{f'_c}A_e \qquad \text{(7-17)}$$

~~$V_c = k\sqrt{f'_c}A_c$ (7-17)~~

…

c = *depth from extreme compression fiber to neutral axis (N.A.) at flexural ~~(1V.A.) atflexural~~ strength (see Figure ~~Fig.~~ 31F-7-7)*

c_o = *distance from concrete cover to center of hoop or spiral (see Figure ~~Fig.~~ 31F-7-7)*

…

Φ = …

…

7.12. ***3107F.2.6.3 Plastic hinge length.*** *The plastic hinge length, L_p (above ground), for steel piles may be computed from Table 31F-7-6 for pile-to-deck connections.*

When the plastic hinge forms in-ground, the plastic hinge length may be determined using Equation (7-21) [7.5]:

$L_p = 2D$ (7-21)

where:

D = pile diameter

~~*The plastic hinge length depends on the section shape and the slope of the moment diagram in the vicinity of the plastic hinge.*~~

~~*For plastic hinges forming in steel piles at the deck/pile interface and where the hinge forms in the steel section rather than in a special connection detail (such as a reinforced concrete dowel connection), allowance should be made for strain penetration into the pile cap. This increase may be taken as 0.25D_p, where D_p is the pile diameter or pile depth in the direction of the applied shear force.*~~

7.13. Add new Table 31F-7-6:

TABLE 31F-7-6

PLASTIC HINGE LENGTH FOR STEEL PILES [7.5]

CONNECTION TYPE	***L_p AT DECK (in.)***
Embedded Pile	*0.5D*
Concrete Plug	$0.30f_{ye}d_b$
Isolated Shell	$0.30f_{ye}d_b+g$
Welded Embed	*0.5D*

d_b = diameter of the dowel (in.)

f_{ye} = design yield strength of dowel (ksi)

D = pile diameter (in.)

g = gap distance from bottom of the deck to edge of pipe pile or external confinement (in.)

7.14. ***3107F.2.6.5 Component acceptance/damage criteria.*** *The maximum allowable strain may not exceed the ultimate value defined in Section 3107F.2.6.4. Table 31F-7-7 ~~31F-7-6~~ provides limiting strain values for each performance level, for both new and existing structures.*

Steel components for noncompact hollow piles ($D_p/t < 0.07 \times E/f_y$) and for all nonseismic loading combinations shall be designed in accordance with AISC 325 [7.10]~~[7.8]~~.

7.15. ***TABLE 31F-7-7 ~~31F-7-6~~ STRUCTURAL STEEL STRAIN LIMITS, ε_u***

7.16. ***3107F.2.6.6 Shear design.*** *The procedures of Section 3107F.2.5.7, which are used to establish V_{design} are applicable to steel piles.*

The shear capacity shall be established from the AISC 325 ~~LRFD~~ [7.10]~~[7.8]~~. For concrete filled pipe, E~~e~~quation (7-15) may be used to determine shear capacity; however, V_{pile} must be substituted for V_s.

… *(7-22)~~(7-21)~~*

…

7.17. ***3107F.2.7.1 Joint shear capacity.*** *The joint shear capacity shall be computed in accordance with ACI 318 [7.7]~~[7.5]~~. For existing MOTs, the method [7.1, 7.2] given below may be used:*

1. … *(7-23)~~(7-22)~~*

…

2. … *(7-24)~~(7-23)~~*

where:

… *(7-25)~~(7-24)~~*

…

… The moment capacity of the connection at which joint failure initiates can be established from Equations (7-27) ~~7-26~~ and (7-28) ~~7-27~~.

… *(7-26)~~(7-25)~~*

3. … *(7-27)~~(7-26)~~*

…

… *(7-28)~~(7-27)~~*

…

… *(7-29)~~(7-28)~~*

4. … *(7-30)~~(7-29)~~*

M_n is defined in Figure 31F-7-4 ~~31F-7-5~~.

… *(7-31)~~(7-30)~~*

Where L_p, is given by Equation (7-5) ~~equation 7-5~~.

… *(7-32)~~(7-31)~~*

…

7.18. ***3107F.2.7.2 Development lLength.*** *The minimum development length, l_{dc}, is:*

… *(7-33)~~(7-32)~~*

…

When the development length is less than that calculated by the Equation (7-33) ~~equation 7-32~~, the moment capacity shall be calculated using a proportionately reduced yield strength, $F_{ye,r}$, for the vertical pile reinforcement:

… *(7-34)~~(7-33)~~*

…

7.19. ***3107F.2.8.2 Nonordinary bBatter pPiles.*** *…*

For fused and seismic release mechanism batter pile systems, a nonlinear modeling procedure shall be used and peer reviewed (Section 3101F.8.2 ~~3101F.6.1~~).

7.20. ***3107F.2.9 Concrete pile caps with concrete deck.*** *Pile caps and decks are capacity protected components. Use the procedure of Section 3107F.2.5.7 to establish the over strength demand of the plastic hinges. Component capacity shall be based on nominal material strengths, and reduction factors according to ACI 318 [7.7] ~~ACI-318 [7.5]~~.*

7.21. ***3107F.2.9.1 Component acceptance/damage criteria.*** *For new pile caps and deck, Level 1 seismic performance shall utilize the design methods in ACI 318 [7.7] ~~ACI-318 [7.5]~~; Level 2 seismic performance shall be limited to the following strains:*

…

Concrete components for all non-seismic loading combinations shall be in accordance with ACI 318 [7.7]~~[7.5]~~.

7.22. ***3107F.2.9.2 Shear capacity (strength).*** *Shear capacity shall be based on nominal material strengths; reduction factors shall be in accordance with ACI 318 [7.7] ~~ACI318 [7.5]~~.*

7.23. ***3107F.2.10 Concrete detailing.*** *For new MOTs, the required development splice length, cover and detailing shall conform to ACI 318 [7.7]~~[7.5]~~, with the following exceptions:*

…

7.24. ***3107F.3.1 Component strength.*** *…*

…

Section 3104F.2.2 discusses existing material properties. At a minimum, the type and grade of wood shall be established. The adjusted reference design ~~stress~~ values per Section 6 of ANSI/AWC NDS [7.11] ~~in the ANSI/AF&PA NDS [7.9]~~ may be used ~~as default values by replacing the Format Conversion Factor of the ANSI/AF&PA NDS [7.9] with the factor 2.8 divided by the Resistance Factor (Table N1 [7.9])~~.

For deck components, the adjusted design stresses shall be limited to the values of the ANSI/AWC NDS [7.11] ~~ANSI/AF&PA NDS [7.9]~~. Piling deformation limits shall be calculated based on the strain limits in accordance with Section 3107F.3.3.3.

The values shown in the ANSI/AWC NDS [7.11] ~~ANSI/AF&PA NDS [7.9]~~ are not developed specifically for MOTs…

The modulus of elasticity shall be based on tests or Section 4 for deck components and Section 6 for timber piles of ANSI/AWC NDS [7.11] ~~the ANSI/AF&PA NDS Table 6A and 6B [7.9]. Alternatively the values shown in Table 31F-7-7 may be used for typical timber piles~~.

7.25. Remove entirely: ***~~TABLE 31F-7-7 [after (7.9)] MODULUS OF ELASTICITY (E) FOR TYPICAL TIMBER PILES~~***

7.26. ***3107F.3.3.2 Displacement capacity.*** *… For pier-type (long unsupported length) vertical piles, three simplified procedures to determine fixity or displacement capacity are described in UFC 4-151-10 [7.12]~~[7.10]~~, UFC 3-220-01A [7.13]~~[7.11]~~ and Chai [7.14]~~[7.12]~~.*

…

The displacement capacity, Δ, for a pile pinned at the top, with effective length, L~~,~~ (see Table 31F-7-8 and UFC 4-151-10 [7.12]~~[7.10]~~), and moment, M, is:

… (7-35)~~(7-34)~~

…

$$\phi_a = \frac{\varepsilon_a}{c} \qquad (7\text{-}36)$$

(struck through:)

$$\phi_a = \frac{\varepsilon_a}{c_u} \qquad (7\text{-}35)$$

where:

ε_a = allowable strain limit according to Section 3107F.3.3.3

c ~~c_u~~ = distance to neutral axis which can be taken as $D_p/2$, where D_p is the diameter of the pile

… (7-36)~~(7-35)~~

…

… (7-37)~~(7-36)~~

…

… *(7-38)(7-37)*

…

… *(7-39)(7-38)*

7.27. ***3107F.3.3.3 Component acceptance/damage criteria****. …*

For new and alternatively, for existing structures ANSI/AWC NDS [7.11] ANSI/AF&PA NDS [7.9] may be used.

Timber components for all non-seismic nonseismic loading combinations shall be designed in accordance with ANSI/AWC NDS [7.11] ANSI/AF&PA NDS [7.9].

7.28. ***3107F.3.3.4 Shear design.*** *…*

… *(7-40)(7-39)*

…

… *(7-41)(7-40)*

…

For the seismic load combinations, the maximum allowable shear stress, $\tau_{capacity}$, is the design shear strength, τ_{design}, from the ANSI/AWC NDS [7.11] ANSI/AF&PA NDS [7.9] multiplied by a factor of 2.8.

… *(7-42)(7-41)*

…

7.29. ***3107F.4 Retaining structures****. Retaining structures constructed of steel or concrete shall conform to AISC 325 [7.10][7.8] or ACI 318 [7.7], [7.5] respectively. For the determination of static and seismic loads on the sheet pile and sheet pile behavior, the following references are acceptable: Ebeling and Morrison [7.15] NCEL [7.13], Strom and Ebeling [7.16][7.14], and PIANC TC-7 (Technical Commentary - 7) [7.17][7.15]. The applied loads and analysis methodology shall be determined by a California registered geotechnical engineer, and may be subject to peer review.*

7.30. ***3107F.5.3 Capacity of mooring and berthing components.*** *The structural and connection capacity of mooring components bolted to the deck shall be established in accordance with AISC 325 [7.10] [7.8], ACI 318 [7.7] ACI-318 [7.5], ANSI/AWC NDS [7.11], ANSI/AF&PA NDS [7.9] as appropriate. …*

7.31. *3107F.6 Symbols.*

A_e	=	…
A_g	=	…
A_h	=	…
A_s	=	Area of slab stirrups on one side of joint of reinforcing steel
$A_{s,deckbottom}$	=	Area of bottom deck steel
A_{sp}	=	…
c	=	…
c_o	=	Distance from oOutside of steel pipe to center of hoop or spiral, or distance from concrete cover to center of hoop or spiral
c_u	=	Value of nNeutral axis depth at ultimate strength of section
D	=	Pile diameter
D^*	=	Reference diameter of 6 ft
d_b	=	Diameter of the longitudinal reinforcement, prestressing strand or dowel, as appropriate Dowel bar diameter
d_c	=	Depth from edge of concrete to center of main reinforcement
d_{bl}	=	Diameter of the longitudinal reinforcement
d_{st}	=	Diameter of the prestressing strand (in)
D	=	Pile diameter or least cross-sectional dimension
D_c	=	Depth of pile cap
D_p	=	…
e	=	…
ε_a	=	…
ε_c	=	Concrete compressive strain
ε_{cm}	=	Maximum extreme fiber compression strain
ε_{cu}	=	Ultimate concrete compressive strain
ε_{acu}	=	Ultimate concrete compressive strain
ε_p	=	Prestressing steel tension strain
ε_s	=	Reinforcing steel tension strain
ε_{sm}	=	…
ε_u	=	…
E	=	…
E_c	=	Modulus of elasticity for concrete
E_s	=	Modulus of elasticity for steel
f'_c	=	…
f'_{cc}	=	…
F_p	=	…
f_p	=	Yield strength of prestressing strands
f_{pye}	=	Design yield strength of prestressing strand (ksi)

f_y	=	…
f_{ye}	=	*Design yield strength of longitudinal reinforcement, prestressing strand or dowel, as appropriate ~~reinforcement~~ (ksi)*
f_{yh}	=	…
f_{yh}	=	…
$f_{y,pile}$	=	…
$f_{ye,\ r}$	=	…
g	=	*Gap distance from bottom of the deck to edge of pipe pile or external confinement (in.)*
h	=	…
h_d	=	…
~~H~~	=	~~*Distance from ground to pile point of contraflexure*~~
I	=	*Moment of inertia*
I_c	=	…
I_e	=	…
I_g	=	…
I_s	=	*Moment of inertia for steel section*
~~K~~	=	~~*Subgrade modulus*~~
k	=	…
k	=	…
L	=	*~~The d~~Distance from the critical section of the plastic hinge to the point of contraflexure (Section 3107F.2.5.3), or effective length (Section 3107F.3.3.2)*
L_p	=	*Plastic hinge length*
l_{dc}	=	…
l_d	=	*Actual ~~Existing~~ development length*
l_{dv}	=	…
M	=	*Maximum allowable moment*
M_c	=	…
$M_{c,r}$	=	*Moment capacity at maximum plastic rotation*
M_n	=	…
M_p	=	*Overstrength moment demand of the plastic hinge (Section 3107F.2.7) ~~Moment as determined from a pushover analysis at displacements corresponding to the damage control limit state~~, or idealized plastic moment capacity (Section 3107F.2.5.4.2)*
M_y	=	…
N	=	…
N_u	=	*External axial compression on pile including seismic load ~~due to earthquake action~~*
ρ_s	=	…
p_t	=	*Nominal principal tension*
~~ρ_t~~	=	~~*Nominal principal tension*~~
r	=	…

s	=	…
t	=	*Steel pPile wall thickness*
Δ	=	*Displacement capacity*
Φ	=	*1.0 for existing structures, and 0.85 for new design*
θ	=	*Angle of critical crack to the pile axis (taken as 30° for existing structures, and 35° for new design)*
θ_p	=	…
α	=	…
ϕ_a	=	…
ϕ_m	=	…
ϕ_p, $\phi_{p,m}$	=	…
ϕ_u	=	…
ϕ'_u	=	…
ϕ_y	=	…
ϕ'_y	=	…
$\tau_{capacity}$	=	*Maximum allowable shear stress*
τ_{design}	=	*Design shear strength*
τ_{max}	=	…
V_c	=	…
v_j	=	*Nominal jJoint shear stress*
V_{design}	=	…
V_{max}	=	…
V_n	=	…
V_p	=	*Contribution to shear strength from axial loads*
V_s	=	*Transverse reinforcement shear capacity (strength)*
V_{pile}	=	…

7.32. *3107F.76 References*

…

[7.5] American Society of Civil Engineers (ASCE), 2014, ASCE/COPRI 61-14 (ASCE/COPRI 61), "Seismic Design of Piers and Wharves," Reston, VA.

[7.6] Port of Long Beach (POLB), 2012 February 29, "Wharf Design Criteria," Version 3.0, Long Beach, CA.

[7.75] American Concrete Institute (ACI), 2014, ACI 318-14 (ACI 318), ACI318-05, 2005, "Building Code Requirements for Structural Concrete (ACI 318-14 318-05) and Commentary (ACI 318R-14 318R-05)," Farmington Hills, MI Michigan.

[7.86] Applied Technology Council (ATC), 1996, ATC-32, "Improved Seismic Design Criteria for California Bridges: Provisional Recommendations," Redwood City, CA.

[7.9~~7~~] Kowalski, M.J. and Priestley, M.J.N., June 1998, “Shear Strength of Ductile Bridge Columns,” Proc. 5th Caltrans Seismic Design Workshop, Sacramento, CA~~ June 1998~~.

[7.10~~8~~] American Institute of Steel Construction Inc. (AISC), 2011, AISC 325-11 (AISC 325)~~, 2005~~, “Steel Construction Manual,” 14th ed.~~ Thirteenth Edition~~, Chicago, IL.

[7.11~~9~~] American Wood Council (AWC), 2014, ANSI/AWC NDS-2015 (ANSI/AWC NDS)~~ American Forest & Paper Association, 2005,~~ “National Design Specification (NDS) for Wood Construction,” ~~ANSI/AF&PA NDS-2005~~, Washington, D.C.

[7.12~~0~~] Department of Defense, 10 September 2001 (Revised 1 September 2012), Unified Facilities Criteria (UFC) 4-151-10, “General Criteria for Waterfront Construction,” Washington, D.C.

[7.13~~1~~] Department of Defense, 16 January 2004, Unified Facilities Criteria (UFC) 3-220-01A, “Deep Foundations,” Washington, D.C.

[7.14~~2~~] Chai, Y.H., “Flexural Strength and Ductility of Extended Pile-Shafts, I: Analytical Model,”~~,~~ Journal of Structural Engineering, May 2002, pp. 586-594.

[7.15~~3~~] Ebeling, Robert M. and Morrison, Ernest E., Jr., November 1992, “The Seismic Design of Waterfront Retaining Structures”, U.S. Army Technical Report ITL-92-11/U.S. Navy Technical Report NCEL TR 939, Dept. of Army, Corps of Engineers, Waterways Experiment Station, Vicksburg, MS~~, November 1992~~.

[7.16~~4~~] Strom, Ralph W. and Robert M. Ebeling, December 2001, “State of the Practice in the Design of Tall, Stiff, and Flexible Tieback Retaining Walls,”~~,~~ Information Technology Laboratory, Engineer Research and Development Center, U.S. Army Corps of Engineers, Vicksburg, MS~~, December 2001~~.

[7.17~~5~~] Permanent International Association of Navigation Congresses (PIANC), “Seismic Design Guidelines for Port Structures,” Technical Commentary-7, Working Group No. 34 of the Maritime Navigation Commission International Navigation Association, A.A. Balkema, Lisse, Netherlands, 2001.

Authority: Sections 8750 through 8760~~ 8755 and 8757~~, Public Resources Code.

Reference: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

Notation
Authority: Sections 8750 through 8760, Public Resources Code.
References: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

DIVISION 8
SECTION 3108F
FIRE PREVENTION, DETECTION AND SUPPRESSION

8.1. ***3108F.2.2 Fire Protection Assessment (N/E).*** *A site-specific Fire Protection Assessment shall be prepared by a registered engineer or a competent fire protection professional. The assessment shall consider the hazards and risks identified per Section 3108F2.1 and shall include, but not be limited to, the elements of pre-fire ~~prefire~~ planning as discussed in Section 9 of API RP 2001 [8.1] and Chapter 19 ~~3~~ of ISGOTT [8.2]. MOT operational and training requirements, as related to fire protection, shall be considered (see 2 CCR 2385 [8.3]). The Fire Protection Assessment shall include goals, resources, organization, strategy and tactics, including the following:*

1. *MOT characteristics (e.g.~~,~~ tanker/manifold, product pipelines, etc.)*
2. *Product types and fire scenarios, including products not regulated by the Division that may impact development of fire scenarios*
3. *…*
4. *Firefighting ~~Fire-fighting~~ capabilities, including availability of water (flow rates and pressure), foam type and associated shelf life, proportioning equipment, and vehicular access ~~[8.1, 8.3]~~*
5. *The selection of appropriate extinguishing agents ~~[8.1, 8.2]~~*
6. *Calculation of water and foam capacities, as applicable, consistent with area coverage requirements ~~[8.1]~~*
7. *…*
8. *Emergency escape routes ~~[8.2, 8.3]~~*
9. *…*
10. *…*
11. *Rescue for terminal and vessel personnel ~~[8.1]~~*
12. *…*
13. *Contingency planning when supplemental fire support is not available. Mutual aid agreements can apply to water and land based support.*
14. *…*

The audit team shall review and field verify the firefighting ~~fire-fighting~~ equipment locations and condition to ensure ~~and may check its~~ operability.

8.2. ***3108F.2.3 Cargo liquid volatility ratings and fire hazard classifications (N/E).*** *The cargo liquid volatility ratings ~~hazard classes~~ are defined in Table 31F-8-1, as either High (H_C) or Low (L_C), depending on the flash point.*

Fire hazard classifications (Low, Medium or High) are defined in Table 31F-8-2, and are based on the cargo liquid volatility ratings ~~hazard class~~ and the sum of all stored and flowing volumes (V_T), prior to the emergency shutdown (ESD) system ~~shut down system (ESD)~~ stopping the flow of oil.

The stored volume (V_S) is the sum of the H_C and L_C ~~liquid hazard class piping~~ volumes (V_{SH} and V_{SL}, respectively)~~, if the piping is not stripped~~.

During a ~~pipeline~~ leak, a quantity of oil is assumed to spill at the maximum cargo flow rate until the ESD is fully effective. The ESD valve closure time shall conform with ~~is required to be completed in 60 seconds if installed prior to November 1, 1980 or in 30 seconds if installed after that date (~~2 CCR 2380~~(h)(3))~~[8.3]. The flowing volume (V_F), calculated in Equation (1-1), is the sum of the H_C and L_C liquid ~~hazard class~~ volumes (V_{FH} and V_{FL}, respectively). ~~, and shall be calculated as follows:~~

~~$V_F = Q_C \times \Delta t \times (1/3,600)$ (8-1)~~

~~***where***~~

~~V_F = Flowing Volume (V_{FH} or V_{FL}) [bbl]~~

~~Q_C = Cargo Transfer Rate [bbl/hr]~~

~~Δt = ESD time, 30 or 60 seconds~~

8.3.

TABLE 31F-8-1
CARGO LIQUID VOLATILITY RATINGS ~~HAZARD CLASS~~

VOLATILITY RATING ~~CLASS~~	***CRITERION***	***REFERENCE***	***EXAMPLES***
Low (L_C)	*Flash Point[1] ≥ 140°F*	*ISGOTT (Chapter 1) [8.2], ~~[8.4]~~) – Nonvolatile*	*#6 Heavy Fuel Oil, residuals, bunker ~~hunker~~*
High (H_C)	*Flash Point[1] <140°F*	*ISGOTT (Chapter 1) [8.2], ~~[8.4]~~) – Volatile*	*Gasoline, JP4, crude oils*

[1] Flash Point is defined per ISGOTT [8.2].

8.4.

TABLE 31F-8-2

FIRE HAZARD CLASSIFICATIONS

CLASS	***STORED VOLUME (bbls)***			***FLOWING VOLUME (bbls)***		***CRITERIA (bbls)****
	Stripped	V_{SL}	V_{SH}	V_{FL}	V_{FH}	
LOW	*y*	*n*	*n*	*y*	*y*	$V_{FL} \geq V_{FH}$, and $V_T \leq 1200$
LOW	*n*	*y*	*n*	*y*	*n*	$V_{SL} + V_{FL} \leq 1200$
MEDIUM	*n*	*n*	*y*	*n*	*y*	$V_{SH} + V_{FH} \leq 1200$
MEDIUM	*y*	*n*	*n*	*y*	*y*	$V_{FH} > V_{FL}$, and $V_T \leq 1200$
HIGH	*y*	*n*	*n*	*y*	*y*	$V_T > 1200$
HIGH	*n*	*y*	*y*	*y*	*y*	$V_T > 1200$
HIGH	*n*	*y*	*n*	*y*	*n*	$V_{SL} + V_{FL} > 1200$
HIGH	*n*	*n*	*y*	*n*	*y*	$V_{SH} + V_{FH} > 1200$

y ≡ yes
n ≡ no
Stripped = product purged from pipeline following product transfer event.
V_{SL} = stored volume of low volatility ~~hazard class~~ product
V_{SH} = stored volume of high volatility ~~hazard class~~ product
V_{FL} = volume of low volatility ~~hazard class~~ product flowing through transfer line during ~~30 - 60 secs.~~ ESD.
V_{FH} = volume of high volatility ~~hazard class~~ product flowing through transfer line during ~~30 - 60 secs.~~ ESD.
$V_T = V_{SL} + V_{SH} + V_{FL} + V_{FH}$ = Total Volume (stored and flowing)

** Quantities are based on maximum flow rate, including simultaneous transfers.*

8.5. ***3108F.3.1.1**… API RP 2003 [8.4] ~~[8.5]~~(N/E).*

8.6. ***3108F.3.1.3** Multi-berth ~~Multiberth~~ terminal piers shall be constructed so as to provide a minimum of 100 ft between adjacent manifolds (N).*

8.7. ***3108F.3.2 Emergency shutdown (ESD) systems.** Emergency shutdown systems are essential to oil spill and fire prevention. These systems may include, but are not limited to, ESD valves, shore isolation valves (SIVs), automatic pump shutdown, controls, actuators and alarms. ~~An essential measure of fire prevention is communications in conjunction with the emergency shutdown.~~ The ESD ~~and isolation~~ systems shall conform to 2 CCR 2380 ~~(h)~~ [8.3] and 33 CFR 154.550 [8.5] ~~[8.6]. An ESD system shall include or~~, and provide:*

~~1. An ESD valve, located near the dock manifold connection or loading arm (N/E).~~

~~2. ESD valves, with "Local" and "Remote" actuation capabilities (N).~~

1~~3~~. Remote actuation stations strategically located, so that ESD valve(s) may be shut within required times (N).

2~~4~~. Multiple actuation stations installed at strategic locations, so that one such station is located more than 100 ft from areas classified as Class I, Group D, Division 1 or 2 per the California

Electrical Code [8.6][8.7]. Actuation stations shall be wired in parallel to achieve redundancy and arranged so that fire damage to one station will not disable the ESD system (N).

35. Communications or control circuits to synchronize simultaneous closure of the shore isolation valves (SIVs) with the shutdown shut down of loading pumps (N).

46. A manual reset to restore the ESD system to an operational state after each initiation (N).

57. An alarm to indicate failure of the primary power source (N).

68. A secondary (emergency) power source (N).

79. Periodic testing of the system (N/E).

810. Fire proofing of motors and control-cables that are installed in areas classified as Class I, Group D, Division 1 or 2 per the California Electrical Code [8.6][8.7]. Fire proofing shall, at a minimum, comply with the recommendations of API Publication 2218 (see in Section 6 of API RP 2218 [8.7][8.8]) (N).

8.8. ***3108F.3.2.1 Emergency shutdown (ESD) valves.*** *ESD valves shall conform to the requirements in Section 3109F.5, as applicable, and the following:*

1. Be located near the dock manifold connection or loading arm (N/E).

2. Have “Local” and “Remote” actuation capabilities (N).

8.9. ***3108F.3.2.23 Shore isolation valves (SIVs).*** *Shore isolation valve(s) shall conform to the requirements in Section 3109F.5, as applicable, and the following:*

1. …

2. …

3. …

4. Be provided with communications or control circuits to synchronize simultaneous closure of the ESD system with the shutdown shut down of loading pumps (N).

5. …

6. …

7. SIVs installed in pipelines carrying H_C hazard class, HC liquids, or at a MOT with a spill risk classification "Medium" or "High" (see Table 31F-1-1 31F-4-1), shall be equipped with "Local" and "Remote" actuation capabilities. Local control SIVs may be motorized and/or operated manually (N).

8.10. ***3108F.4 Automated F fire detection system.*** *An MOT shall have a permanently installed automated fire detection or sensing system (N).*

Fire detection systems shall be tested and maintained per the manufacturer or the local enforcing agency requirements. Specifications shall be retained. The latest testing and maintenance records shall be readily accessible to the Division (N/E).

8.11. ***3108F.5 Fire alarms.*** *Automatic and manual fire alarms shall be provided at strategic locations. The fire alarm system shall be arranged to provide a visual and audible alarm that can be readily discerned by all personnel at the MOT and vessel personnel involved in the transfer operations. Additionally, visual and audible alarms shall be displayed at the MOT's Facility's C control C center (N/E).*

…

Fire alarms shall be tested and maintained in accordance with NFPA 72 [8.8] NFPA-72 [8.9]…

8.12. ***3108F.6 Fire suppression.*** *Table 31F-8-3 gives the minimum provisions for fire-water flow rates and fire extinguishers. The table includes consideration of the fire hazard classification (Low, Medium or High), the cargo liquid volatility rating hazard class (Low or High) and the vessel or barge size. The minimum provisions may have to be augmented for multi-berth terminals or those conducting simultaneous transfers, in accordance with the risks identified in the Fire Protection Assessment. For fire water and foam piping and fittings, see Section 3109F.7.*

8.13.

TABLE 31F-8-3
MINIMUM FIRE SUPPRESSION PROVISIONS (N/E)

FIRE HAZARD CLASSIFICATION (From Table 31F-8-2)	***VESSEL AND CARGO LIQUID VOLATILITY RATING HAZARD CLASS (From Table 31F-8-1)***	***MINIMUM PROVISIONS***
LOW	*Barge with L_C (including drums)*	***500 gpm of water*** *2 x 20 lb portable dry chemical and 2 x 110 lb wheeled dry chemical extinguishers or the equivalent.*
	Barge with H_C (including drums) *Tankers < 50 KDWT, handling L_C or H_C*	***1,500 gpm of water*** *2 x 20 lb portable dry chemical and 2 x 165 lb wheeled dry chemical extinguishers or the equivalent*
MEDIUM	*Tankers < 50 KDWT, handling L_C*	***1,500 gpm of water*** *2 x 20 lb portable dry chemical and 2 x 165 lb wheeled dry chemical extinguishers or the equivalent.*
	Tankers < 50 KDWT, handling H_C	***2,000 gpm of water*** *4 x 20 lb portable dry chemical and 2 x 165 lb wheeled dry chemical extinguishers or the equivalent.*
HIGH	*Tankers < 50 KDWT, handling L_C or H_C*	***3,000 gpm of water*** *4 x 20 lb portable dry chemical and 2 x 165 lb wheeled dry chemical extinguishers or the equivalent.*
LOW, MEDIUM, HIGH	*Tankers > 50 KDWT, handling L_C or H_C*	***3,000 gpm of water*** *6 x 20 lb portable dry chemical and 4 x 165 lb wheeled dry chemical extinguishers or the equivalent.*

Notes: L_C and H_C are defined in Table 31F-8-1. KDWT= Dead Weight Tons (Thousands)

8.14. ***3108F.6.2 Fire hydrants.*** *Hydrants shall be located not greater than 150 ft apart, along the wharf and not more than 300 ft apart on the approach trestle [8.2][8.4] (N).*

…

8.15. ***3108F.6.3 Fire water.*** *… Water-based fire protection systems shall be tested and maintained per California NFPA 25 [8.9][8.10],…*

1. *…*
2. *…*
3. *…*
4. *Hose connections for fireboats or tugboats shall be provided on the MOT fire water line, and at least one connection shall be an international shore fire connection at each berth [8.2][8.4]. Connections shall be installed at a safe access distance from the high-risk areas such as sumps, manifolds and loading arms (N/E).*

8.16. ***3108F.6.4 Foam supply (N/E).*** *…*

Fixed foam proportioning equipment shall be located at a distance of at least 100 ft from the high-risk areas such as sumps, manifolds and loading arms, except where hydraulic limits of the foam delivery system require closer proximity.

…

8.17. ***3108F.7 Critical systems seismic assessment (N/E).*** *Fire detection and protection systems, and emergency shutdown systems shall have a seismic assessment per Section 3104F.65.3.*

For firewater piping and pipeline systems, see Section 3109F.7. For anchors and supports, see Section 3109F.4.

For equipment anchorages and supports, see Section 3110F.8.

8.18. *3108F.8 References.*

[8.1] American Petroleum Institute (API), 2012 1998, API Recommended Practice 2001 (API RP 2001), "Fire Protection in Refineries," 9th 7th ed., Washington, D.C.

[8.2] International Chamber of Shipping (ICS), Oil Companies International Marine Forum (OCIMF), International Association of Ports and Harbors (IAPH), 2006, "International Safety Guide for Oil Tankers and Terminals (ISGOTT)," 5th ed., Witherby, London.

[8.2] Oil Companies International Marine Forum (OCIMF), 1987, "Guide on Marine Terminal Fire Protection and Emergency Evacuation," 1st ed., Witherby, London.

[8.3] California Code of Regulations (CCR), Title 2, Division 3, Chapter 1, Article 5 – Marine Terminals Inspection and Monitoring (2 CCR 2300 et seq.) 2 CCR 2300-2407 (Title 2, California Code of Regulations, Sections 2300-2407).

[8.4] International Chamber of Shipping (ICS), Oil Companies International Marine Forum (OCIMF), International Association of Ports and Harbors (IAPH), 2006, "International Safety Guide for Oil Tankers and Terminals (ISGOTT)," 5th ed., Witherby, London.

[8.45] American Petroleum Institute (API), 2008 1998, API Recommended Practice 2003 (API RP 2003), "Protection Against Ignitions Arising Out of Static, Lightning, and Stray Currents," 7th 6th ed., Washington, D.C.

[8.56] Code of Federal Regulations (CFR), Title 33, Section 154.550 – Emergency Shutdown (33 CFR 154.550) 33 CFR 154.550 (Title 33, Code of Federal Regulations, Section 154.550).

[8.67] California Code of Regulations (CCR), Title 24, Part 3, California Electrical Code National Fire Protection Association, 2008, NFPA 70 (Article 500), "National Electrical Code," Quincy, MA.

[8.78] American Petroleum Institute (API), 2013 1999, API Recommended Practice Publication 2218 (API RP 2218), "Fireproofing Practices in Petroleum and Petrochemical Processing Plants," 3rd 2nd ed., Washington, D.C.

[8.89] National Fire Protection Association (NFPA), 2010, NFPA 72, "National Fire Alarm and Signaling Code," Quincy, MA. For edition, see California Code of Regulations (CCR), Title 24, Part 2, Chapter 35 – Referenced Standards.

[8.910] National Fire Protection Association (NFPA), 2011, California NFPA 25, "Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems," California ed., Quincy, MA. For edition, see California Code of Regulations (CCR), Title 24, Part 2, Chapter 35 – Referenced Standards.

Authority: Sections 8750 through 8760 8755 and 8757, Public Resources Code.

Reference: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

Notation
Authority: Sections 8750 through 8760, Public Resources Code.
References: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

DIVISION 9
SECTION 3109F
PIPING AND PIPELINES

9.1. ***3109F.2 Oil piping and pipeline systems.*** *…*

…

13. If a pipeline is "out-of-service" for 3 or more years, it will require a valid and certified Static Liquid Pressure Test (SLPT) and API 570 inspection [9.4] ~~Division approval~~ prior to Division approval for re-use (E).

14. New piping and pipeline systems require a valid and certified Static Liquid Pressure Test (SLPT) [9.4] and Division approval, prior to operation.

9.2. ***3109F.5.1 Valves and fittings.*** *Valves and fittings shall meet the following requirements:*

1. …

2. Conform to Section 8 of API Standard 2610 [9.1] (N/E).

3. …

4. Nonductile iron, cast iron, and low-melting temperature metals shall not be used in any hydrocarbon service~~, fire water or foam service~~ (N/E).

5. Double-block and bleed valves shall be used for manifold valves (N/E). ~~(N/E).~~

6. Isolation valves shall be fire-safe~~,~~ in accordance with API Standard 607 [9.11] (N).

7. …

8. Pressure relief devices shall be used in any closed piping system that has the possibility of being over pressurized due to temperature increase (thermal relief valves) ~~or surging~~ (N/E).

9. Pressure relief devices shall be used in any piping system that has the possibility of being over pressurized due to surging, considering all plausible normal and abnormal operational scenarios in accordance with ASME B31.4 [9.3] (N/E).

10~~9~~. Pressure relief devices shall be sized in accordance with API RP 520 [9.12] (N). Set pressures and accumulating pressures shall be in accordance with API RP 520 [9.12] (N/E).

11~~10~~. …

12~~11~~. Threaded, socket-welded, flanged and welded fittings shall conform to Section 8 of API Standard 2610 [9.1] (N/E).

13. ESD valves and SIVs shall also conform to the requirements of Sections 3108F.3.2.1 and 3108F.3.2.2.

9.3. ***3109F.5.2 Valve actuators (N/E).***

1. …

2. …

3. …

4. …

5. …

6. ESD valve and SIV actuators shall also conform to the requirements of Section 3108F.3.2.

9.4. ***3109F.6 Utility and auxiliary piping and pipeline systems.*** *Utility and auxiliary piping includes service for:*

1. Stripping and sampling

2. Vapor control

~~3. Fire water and foam~~

3.~~4.~~ Natural gas

4.~~5.~~ Compressed air, venting and nitrogen

Stripping and sampling piping shall conform to Section 3109F.2 (N/E).

Vapor return lines and VOC vapor inerting and enriching (natural gas) piping shall conform to 33 CFR 154.2100(b)~~808~~ [9.13] ~~and API RP 1124 [9.14]~~ (N/E).

~~Firewater and foam piping and fittings shall meet the following requirements:~~

~~1. Conform to ASME B16.5 [9.15]~~

~~2. Fire mains shall be carbon steel pipe (N/E)~~

~~3. High density polyethylene (HDPE) piping may be used for buried pipelines (N/E)~~

~~4. Piping shall be color-coded (N/E)~~

Compressed air, venting and nitrogen piping and fittings shall conform to ASME B31.3 ~~B 31.3~~ [9.2] (N). ~~Utility and auxiliary piping shall have external visual inspections, similar to that defined in Section 10.1 of API 574 [9.16] (N/E).~~

9.5. ***3109F.7 Fire piping and pipeline systems.*** *Firewater and foam piping and fittings shall meet the following requirements:*

1. Conform to NFPA 11 [9.14], NFPA 24 [9.15], and ASME B16.5 [9.16] (N/E).

2. Fire mains shall be carbon steel pipe (N/E).

3. High density polyethylene (HDPE) piping may be used for buried pipelines (N/E).

4. Piping and appurtenances shall be color-coded per local jurisdiction requirements or per ASME A13.1 [9.17] (N/E).

5. Pipeline stress analysis shall be performed for firewater pipelines per Section 3109F.3 (N).

6. External visual inspection shall be performed per Section 3102F.3.5.5 (N/E).

9.6. ***3109F.87 References.***

[9.1] American Petroleum Institute (API), 2005, API Standard 2610 (R2010), "Design, Construction, Operation, Maintenance, and Inspection of Terminal and Tank Facilities," 2nd ed., Washington, D.C.

[9.2] American Society of Mechanical Engineers (ASME), 2015 2010, ASME B31.3-2014 (ASME B31.3), "Process Piping," New York.

[9.3] American Society of Mechanical Engineers (ASME), 2012 2009, ASME B31.4-2012 (ASME B31.4), "Pipeline Transportation Systems for For Liquid Hydrocarbons and And Other Liquids," New York.

[9.4] California Code of Regulations (CCR), Title 2, Division 3, Chapter 1, Article 5.5 – Marine Terminal Oil Pipelines (2 CCR 2560 et seq.) 2 CCR 2560 - 2571 (Title 2, California Code of Regulations (CCR), Sections 2560-2571).

[9.5] American Society of Mechanical Engineers (ASME), 2008, ASME B31E B31.E, "Standard for the Seismic Design and Retrofit of Above-Ground Piping Systems," New York.

[9.6] …

[9.7] CalARP Program Seismic Guidance Committee, December 2013 September 2009, "Guidance for California Accidental Release Prevention (CalARP) Program Seismic Assessments," Sacramento, CA.

[9.8] …

[9.9] American Petroleum Institute (API), 2009 1997, API Standard 609, "Butterfly Valves: Double Flanged, Lug- and Wafer-Type," 7th 5th ed., Washington, D.C.

[9.10] American Society of Mechanical Engineers (ASME), 2013 1996, ASME B16.34-2013 (ASME B16.34), "Valves Flanged Threaded and And Welding End," New York.

[9.11] American Petroleum Institute (API), 2010 1996, API Standard 607, "Fire Test for Soft-Seated Quarter-Turn Valves and Valves Equipped with Nonmetallic Seats," 6th 4th ed., 1993 (reaffirmed 4/1996), Washington, D.C.

[9.12] American Petroleum Institute (API), 2000, API Recommended Practice 520 P1 and P2 (API 520), "Sizing, Selection, and Installation of Pressure-relieving Devices, Part 1 in Refineries, Part I – Sizing and Selection," 2014, 9th 7th ed., and "Sizing, Selection, and Installation of Pressure-Relieving Devices in Refineries – Part 2 II – Installation," 2015, 6th 2003, 5th ed., Washington, D.C.

[9.13] Code of Federal Regulations (CFR), Title 33, Section 154.2100 – Vapor Control System, General (33 CFR 154.2100) 33 CFR 154.808 – Vapor Control Systems, General (Title 33, Code of Federal Regulations (CFR), Section 154.808).

[9.14] American Petroleum Institute (API), 1991, Recommended Practice 1124 (API RP 1124), "Ship Barge, and Terminal Hydrocarbon Vapor Collection Manifolds," 1st ed., Washington, D.C.

[9.14] National Fire Protection Association (NFPA), NFPA 11, "Standard for Low-, Medium-, and High-Expansion Foam," Quincy, MA. For edition, see California Code of Regulations (CCR), Title 24, Part 2, Chapter 35 – Referenced Standards.

[9.15] National Fire Protection Association (NFPA), NFPA 24, "Standard for the Installation of Private Fire Service Mains and Their Appurtenances," Quincy, MA. For edition, see California Code of Regulations (CCR), Title 24, Part 2, Chapter 35 – Referenced Standards.

[9.165] American Society of Mechanical Engineers (ASME), 2013 1996, ASME B16.5-2013 (ASME B16.5), "Pipe Flanges and Flanged Fittings," New York.

[9.16] American Petroleum Institute (API), 2009, API RP 574, "Inspection Practices for Piping System Components," 3rd ed., Washington, D.C.

[9.17] American Society of Mechanical Engineers (ASME), 2007, ASME A13.1-2007 (R2013) (ASME A13.1), "Scheme for the Identification of Piping Systems," New York.

Authority: Sections 8750 through 8760 8755 and 8757, Public Resources Code.

Reference: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

Notation
Authority: Sections 8750 through 8760, Public Resources Code.
References: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

DIVISION 10
SECTION 3110F
MECHANICAL AND ELECTRICAL EQUIPMENT

10.1. ***3110F.2.1 General criteria.*** *Marine loading arms and ancillary systems shall conform to ASME B31.3 ~~2 CCR 2380 (b)~~ [10.1], 33 CFR 154.510 [10.2] and ~~the~~ OCIMF “Design and Construction Specification for Marine Loading Arms~~,~~” [10.3].*

The following shall be considered when determining the loading arm maximum allowable extension limits:

1. *Vessel sizes and manifold locations*
2. *Lowest-low water level (datum)*
3. *Highest-high water level*
4. *Maximum vessel surge and sway*
5. *Maximum width of fendering system*

For each loading arm, the maximum allowable movement envelope limits shall comply with 2 CCR 2380 [10.4].

Loading arms shall meet the seismic criteria defined in Section 3104F.2.1 and the procedure in Section 8.5.3 of ASCE/COPRI 61 [10.5] (N).

10.2. ***3110F.2.2.1 Pressure and control systems (N).***

1. *Pressure gauges shall be mounted in accordance with ASME B40.100~~-1 998~~ [10.6]~~[10.4]~~.*
2. *The hydraulic drive cylinders shall be mounted and meet either the mounting requirements of NFPA T3.6.7 R3 ~~ANSI/(NFPA) T3. 6.7 R2 -1 996~~ [10.7]~~[10.5]~~ or equivalent.*
3. *…*
4. *…*

10.3. ***3110F.2.2.2 Electrical components (N).*** *…*

1. *…Article 430 of the California Electrical Code ~~National Electrical Code (NEC)~~ [10.8]~~, [10.6]~~.*
2. *…Article 430 of the~~,~~ California Electrical Code ~~NEC~~ [10.8]~~[10.6]~~.*
3. *…Articles 500 and 501 of the California Electrical Code ~~NEC~~ [10.8]~~[10.6]~~… with Article 504 of the~~,~~ California Electrical Code ~~NEC~~ [10.8]~~[10.6]~~ and ~~ANSI/~~UL Std. No. 913 [10.9]~~[10.7]~~.*
4. *…Article 430 of the~~,~~ California Electrical Code ~~NEC~~ [10.8]~~[10.6]~~ and Section 3111F.*

…

10.4. ***3110F.2.2.3 Remote operation.*** *…*

…

… 2 CCR 2370~~(e)~~ [10.4]~~[10.8]~~ and 47 CFR Part 15 [10.10] ~~47CFR Part 15 [10.9]~~…

10.5. ***3110F.3 Oil transfer hoses (N/E).*** *Hoses for oil transfer service shall be in compliance with 2 CCR 2380 (a) [10.4][10.10] and 33 CFR 154.500 1 54.500 [10.11].*

Hoses with nominal diameters of 6 inches or larger shall have flanges that meet ASME B16.5 ANSIB1 6.5 [10.12]. H, or hoses with nominal diameters of 6 inches 4 inches or less may have quick disconnect fittings provided that they meet ASTM F 1122 [10.13] F-1122 [10.13].

The minimum hose length shall safely accommodate the vessel's size and maximum movements during transfer operations and mooring (see Section 3105F.2).

10.6. ***3110F.4 Lifting equipment: winches and cranes.*** *Lifting equipment for oil service activities, other activities (if operation or failure could cause an oil release) or spill response, shall conform to the provisions in Sections 3110F.4.1 and 3110F.4.2. [10.14], [10.15], [10.16] and [10.1 7]. Electrical equipment shall conform to the provisions of Section 3111F.*

Lifting equipment inspection and maintenance shall conform to ASME B30.4 [10.14], ASME B30.7 [10.15] and ASME HST-4 [10.16], as applicable. Inspections by qualified personnel shall be performed annually. Inspection and maintenance records shall be retained.

10.7. ***3110F.4.2 Cranes (N/E).***

1. *…*
2. *…*
3. *…*
4. *…*
5. *…*
6. *Safety systems including devices that affect the safe lifting and handling, such as interlocks, limit switches, load/moment and overload indicators with shutdown capability [10.17], emergency stop switches, radius and locking indicators, shall be provided [10.18].*

10.8. ***3110F.5 Shore-to-vessel access for personnel.*** *…*

Shore-to-vessel access for personnel shall conform to 29 CFR 1918.22 [10.18][10.19], Sections 19.B(b) and 21.E(b) of USACE EM 385-1-1 [10.19][10.20], Chapter 16.4 of ISGOTT [10.20][10.21] and the following:

1. *…*
2. *…*
3. *…*
4. *…*
5. *…*
6. *…*
7. *…*

~~*8. Under no circumstances shall the operating inclination of the walkway exceed 60 degrees from the horizontal or the maximum angle recommended by the manufacturer, whichever is less (N/E).*~~

8~~9~~. The undersides of aluminum gangways shall be protected with hard plastic or wooden strips to prevent being dragged or rubbed across any steel deck or component (N/E).

10.9. ***3110F.6 Oil s~~S~~umps~~, discharge containment~~ and ancillary equipment.*** *Oil s~~S~~umps~~, discharge containment~~ and ancillary equipment shall conform to ~~2 CCR 2380(f) [10.22], 33 CFR 1 54.530 [10.23] and~~ the following:*

…

10.10. ***3110F.7 Vapor control systems.*** *…33 CFR 154.2000~~800~~ through 154.2181~~850~~ [10.21]~~[10.24]~~ and API Standard 2610 [10.22]~~[10.25]~~. …*

10.11. ***3110F.8 Equipment anchors and supports.*** *…Section 6.4 of FEMA 450 [10.23]~~[10.26]~~. …*

… CalARP [10.24]~~[10.27]~~, FEMA 356 [10.25]~~[10.28]~~ or ASCE Guidelines [10.26]~~[10.29]~~.

10.12. ***3110F.9 Spill prevention e~~E~~quipment and systems maintenance (N/E).*** *Mechanical and electrical equipment critical to oil spill prevention and safety, such as, but not limited to: mooring line quick release and loading arm quick disconnect systems, shall be maintained and tested as per the manufacturer's recommendations (N/E).*

…

10.13. ***3110F.10 Pumps (N/E).*** *…*

… API Standard 2610 [10.22]~~[10.25]~~. … California NFPA 25 [10.27]~~[10.30]~~,…

10.14. ***3110F.12 References.***

[10.1] American Society of Mechanical Engineers (ASME), 2015, ASME B31.3-2014 (ASME B31.3), "Process Piping," New York.

~~*[10.1] 2 CCR 2380(b), Title 2, California Code of Regulations, Section 2380(b), Loading Arms.*~~

[10.2] Code of Federal Regulations (CFR), Title 33, Section 154.510 – Loading Arms (33 CFR 154.510) ~~33 CFR 154.510, Title 33 Code of Federal Regulations Section 154.510.~~

[10.3] Oil Companies International Marine Forum (OCIMF), 1999, "Design and Construction Specification for Marine Loading Arms," 3rd ed., Witherby, London.

[10.4] California Code of Regulations (CCR), Title 2, Division 3, Chapter 1, Article 5 – Marine Terminals Inspection and Monitoring (2 CCR 2300 et seq.)

[10.5] American Society of Civil Engineers (ASCE), 2014, ASCE/COPRI 61-14 (ASCE/COPRI 61), "Seismic Design of Piers and Wharves", Reston, VA.

[10.6~~4~~] American Society of Mechanical Engineers (ASME), 2013 ~~2000~~, ASME B40.100-2013 (ASME B40.100) ~~1998~~, "Pressure Gauges and Gauge Attachments," New York.

[10.7~~5~~] National Fluid Power Association (NFPA), 2009, NFPA T3.6.7 R3-2009 (R2012) (NFPA T3.6.7 R3) ~~1996, ANSI/(NFPA) T3. 6. 7R2-1996~~, "Fluid Power Systems and Products – Square Head Industrial Cylinders - Mounting Dimensions," Milwaukee, WI.

[10.8~~6~~] California Code of Regulations (CCR), Title 24, Part 3, California Electrical Code. ~~National Fire Protection Association, 2002, NFPA 70, "National Electrical Code," Quincy, MA.~~

[10.9~~7~~] Underwriters Laboratory, Inc., 2013 ~~1997~~, UL Standard No. 913, "Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations," ~~ANSI/UL Standard No. 913,~~ 8th ~~5th~~ ed., Northbrook, IL.

~~[10.8] 2 CCR 2370(e), Title 2 California Code of Regulations, Section 2370(e).~~

[10.10~~9~~] Code of Federal Regulations (CFR), Title 47, Part 15 – Radio Frequency Devices (47 CFR 15) ~~47 CFR Part 15 Private Land Mobile Radio Services, Title 47 Code of Federal Regulations (CFR).~~

~~[10.10] 2 CCR 2380(a), Title 2, California Code of Regulations, Section 2380(a).~~

[10.11] Code of Federal Regulations (CFR), Title 33, Section 154.500 – Hose Assemblies (33 CFR 154.500) ~~33 CFR 154.500 Hose Assemblies, Title 33 Code of Federal Regulations Section 154.500.~~

[10.12] American Society of Mechanical Engineers (ASME), 2013 ~~1996~~, ASME~~/ANSI~~ B16.5-2013 (ASME B16.5), "Pipe Flanges and Flanged Fittings," 13th ed., New York.

[10.13] American Society for Testing and Materials (ASTM), 2010, ASTM F1122-04(2010) (ASTM F1122) ~~2001, ASTMF-1122-87 (1998)~~, "Standard Specification for Quick Disconnect Couplings (6 in. NPS and Smaller)," 4th ed., West Conshohocken, PA.

~~[10.14] 29 CFR 1918, Subpart F, Title 29 Code of Federal Regulations Section 1918, Subpart F.~~

[10.14~~5~~] American Society of Mechanical Engineers (ASME), 2010 ~~1996~~, ASME B30.4-2010 (ASME B30.4) ~~–1996~~, "Portal Tower and Pedestal Cranes," 10th ed., New York.

[10.15~~6~~] American Society of Mechanical Engineers (ASME), 2011 ~~2002~~, ASME B30.7-2011 (ASME B30.7) ~~– 2001~~, "Winches ~~Base Mounted Drum Hoists~~," 11th ed., New York.

[10.16~~7~~] American Society of Mechanical Engineers (ASME), 1999, ASME HST-4-1999 (R2010) (ASME HST-4), "Performance Standard for Overhead Electric Wire Rope ~~Wire-Rope~~ Hoists," New York.

[10.17~~8~~] Code of Federal Regulations (CFR), Title 29, Section 1917.46 – Load Indicating Devices (29 CFR 1917.46) ~~29 CFR 1917.46, Title 29 Code of Federal Regulations Section 1917.46 Load Indicating Devices.~~

[10.18~~9~~] Code of Federal Regulations (CFR), Title 29, Section 1918.22 – Gangways (29 CFR 1918.22) ~~29 CFR 1918.22, Title 29 Code of Federal Regulations Section 1918.22, Gangways.~~

[10.19~~20~~] US Army Corps of Engineers (USACE), 2008 (05 Jul 11) ~~1996~~, EM 385-1-1, "Safety and Health Requirements Manual, Sections 19.B~~(b)~~ and 21.E~~(b)~~," ~~EM 385-1 -1,~~ Washington, D.C.

[10.20~~1~~] International Chamber of Shipping (ICS), Oil Companies International Marine Forum (OCIMF), International Association of Ports and Harbors (IAPH), 2010, ~~Chapter 16.4, Ship/Shore Access,~~ "International Safety Guide for Oil Tankers and Terminals (ISGOTT)," 5th ed. ~~2006~~, Witherby, London.

[10.22] 2 CCR 2380(f), Title 2, California Code of Regulations, Section 2380(f), Small Discharge Containment.

[10.23] 33 CFR 154.530, Title 33, Code of Federal Regulations, Section 154.530 Small Discharge Containment.

[10.214] Code of Federal Regulations (CFR), Title 33, Sections 154.2000 through 154.2250 – Vapor Control Systems (33 CFR 154.2000 et. seq.) 33 CFR 154.800 through 154.850, Title 33 Code of Federal Regulations, Sections 154.800 through 154.850.

[10.225] American Petroleum Institute (API), 2005, API Standard 2610 (R2010), "Design, Construction, Operation, Maintenance, and Inspection of Terminal and Tank Facilities," 2nd ed., Washington, D.C.

[10.236] Federal Emergency Management Agency, 2003, FEMA 450, "NEHRP Recommended Provisions for Seismic Regulations for New Buildings and Other Structures (FEMA 450)," Part 1 — Provisions, Washington, D.C.

[10.247] CalARP Program Seismic Guidance Committee, December 2013 September 2009, "Guidance for California Accidental Release Prevention (CalARP) Program Seismic Assessments," Sacramento, CA.

[10.258] Federal Emergency Management Agency (FEMA), Nov. 2000, FEMA 356, "Prestandard and Commentary for the Seismic Rehabilitation of Buildings," Washington, D.C.

[10.269] American Society of Civil Engineers (ASCE), 2011 1997, "Guidelines for Seismic Evaluation and Design of Petrochemical Facilities," 2nd ed., New York, NY.

[10.2730] National Fire Protection Association (NFPA), 2011, California NFPA 25, "Standard for the Inspection, Testing, and Maintenance of Water-Based Fire Protection Systems," California ed., Quincy, MA. For edition, see California Code of Regulations (CCR), Title 24, Part 2, Chapter 35 – Referenced Standards.

Authority: Sections 8750 through 8760 8755 and 8757, Public Resources Code.

Reference: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

Notation
Authority: Sections 8750 through 8760, Public Resources Code.
References: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

DIVISION 11
SECTION 3111F
ELECTRICAL SYSTEMS

11.1. ***3111F.1 General.*** *This section provides minimum standards for electrical systems at marine oil terminals.*

Electrical systems include the incoming electrical service and components, the electrical distribution system, branch circuit cables and the connections, including, but not limited to:. Also included are:

…

All electrical systems shall conform to API RP 540 [11.1] and the California National Electrical Code (NEC) [11.2].

…

11.2. ***3111F.2 Hazardous area designations and plans (N/E).*** *Area classifications shall be determined in accordance with API RP 500 [11.3], API RP 540 [11.1] and the NEC, Articles 500, 501, 504, 505 and 515 of the California Electrical Code [11.2]. A marine oil terminal shall have a current set of scaled plan drawings, with clearly designated areas showing the hazard class, division and group. The plan view shall be supplemented with sections, elevations and details to clearly delineate the area classification at all elevations starting from low water level. The drawings shall be certified by a professional aprofessional electrical engineer. The plans shall be reviewed, and revised when modifications to the structure, product or equipment change hazardous area identifications or boundaries.*

11.2a. ***3111F.3 Identification and tagging.*** *All electrical equipment, cables and conductors shall be clearly identified by means of tags, plates, color coding or other effective means to facilitate troubleshooting and improve safety, and shall conform to the identification carried out for the adjacent on-shore facilities (N). Topics for such identification are found in the NEC Articles 110, 200, 210, 230, 384, 480 and 504 of the California Electrical Code [11.2]. Existing electrical equipment (E) shall be tagged.*

…

11.3. ***3111F.4 Purged or pressurized enclosures for equipment in hazardous locations (N/E).*** *Purged or pressurized enclosures shall be capable of preventing the entry of combustible gases into such spaces, in accordance with NFPA 496 [11.4]. Special emphasis shall be placed on reliability and ease of operation. The pressurizing equipment shall be electrically monitored and alarms shall be provided to indicate failure of the pressurizing or purging systems.*

Pressurized control rooms shall conform to Chapter 7 of NFPA 496 [11.4].

11.4. ***3111F.5 Electrical service.*** *Where critical circuits are used for spill prevention, fire control or life safety, an alternative service derived from a separate source and conduit system, shall be located at a safe distance from the main power service. A separate feeder from a double-ended substation or other source backed up by emergency generators will meet this requirement. An stored energy emergency uninterrupted power system service (UPS) (SEEPS) shall be provided for control and supervisory circuits associated with ESD systems (N), see Section 3111F.5.1.*

1. *…*
2. *Wiring in fireproofed conduits shall be derated 15 percent to account for heat buildup during normal operation. Type MI (mineral insulated, metal sheathed per the California Electrical Code [11.2]) cables may be used in lieu of fireproofing of wiring (N).*
3. *…*
4. *…*

…

11.5. ***3111F.5.1 Emergency power systems.*** *Emergency power systems shall be installed (N) and maintained (N/E) per NFPA 110 [11.5] NFPA-110 [11.6]. … SEEPS shall be installed (N) and maintained (N/E) per NFPA 111 [11.6] NFPA-111 [11.7].*

11.6. ***3111F.6 Grounding and bonding (N/E).***

1. *All electrical equipment shall be effectively grounded as per NEC Article 250 of the California Electrical Code [11.2]. …*
2. *…*
3. *Bonding of vessels to the MOT structure is not permitted (2 CCR 2341 (f)) [11.7][11.5].*
4. *…*
5. *…*

11.7. ***3111F.8 Illumination (N/E).*** *Lighting shall conform to 2 CCR 2365 [11.7][11.8] and 33 CFR 154.570 (d) [11.8][11.9].*

11.8. ***3111F.9.1 Communication systems (N/E).*** *Communication systems shall comply with 2 CCR 2370 [11.7][11.10], and conform to Section 6 of OCIMF "Guide on Marine Terminal Fire Protection and Emergency Evacuation" [11.9][11.11].*

11.9. ***3111F.9.2 Overfill monitoring and controls (N/E).*** *Overfill protection systems shall conform to Appendix C of API Standard RP 2350 [11.10][11.12]. … Where vessel or barge overfill sensors and alarms are provided, they shall comply with 33 CFR 154.2102812 [11.11][11.13].*

…

11.10. *3111F.10 Cathodic Corrosion pProtection Systems (CPS) (N/E).*

CPS operating, testing, and maintenance criteria for underwater structures shall conform to UFC 3-570-02N [11.12]. Structure-to-electrolyte potential measurements shall be taken at least annually. CPS operating, testing, and maintenance criteria for buried and submerged pipelines shall conform to API 570 [11.13].

All electrical insulating and isolating devices for protection against static, stray and impressed currents shall be tested in accordance with 2 CCR 2341 and 2380 [11.7].

CPS design criteria and location of anodes, electrical leads and rectifiers shall be documented and retained. Periodic CPS measurements, test data and inspection findings shall be retained.

11.11. ***3111F.10.1 Corrosion assessment (N/E).*** *An assessment shall be performed to determine the existing and potential corrosion. This assessment shall include all steel or metallic components, including the structure, pipelines, supports or other ancillary equipment, with drawings and specifications for corrosion prevention/protection. This assessment shall be performed by a licensed professional engineer, using the methods and criteria prescribed in [11.14].*

11.12. ***3111F.10.2 Inspection, testing and records (N/E).*** *For sacrificial anode systems, periodic underwater inspections shall be performed and observations recorded. For impressed current systems, monthly rectifier readings and annual potential readings of the protected components shall be taken. If potential readings for steel structures are outside of acceptable limits (between -0.85 [11.15] and -1.10 Volts), corrective actions shall be taken. Voltage drops other than across the structure-to-electrolyte boundary must be considered for valid interpretations of potential measurement. Consideration is understood to mean the application of sound engineering practice in determining the significance of voltage drops by methods such as:*

1. *Measuring or calculating voltage drop(s)*
2. *Reviewing historical performance of the cathodic protection system (CPS)*
3. *Evaluating the physical and electrical characteristics of the structure and the environment*
4. *Determining whether or not there is physical evidence of corrosion*

All isolating sections shall be tested immediately after installation or replacement, and, at a minimum, annually. Test results shall be recorded and documented. Electrical tests on insulating flanges shall make use of specialized insulator testers. The test instrument shall make use of RF signals, capacitive measurements or other means to clearly determine whether an insulating flange is shorted or open circuited without being affected by pipe-to-soil potentials, cathodic protection voltages or whether it is buried or exposed.

The cathodic protection inspection for buried or submerged pipelines shall conform to API 570 [11.16].

Insulating and isolating arrangements for protection against static, stray and impressed currents shall be tested in accordance with 2 CCR 2341(d) and 2380 [11.17].

11.13. ***3111F.12 References.***

[11.1] American Petroleum Institute (API), 1999, API Recommended Practice 540 (R2004) (API RP 540), "Electrical Installations in Petroleum Processing Plants," 4th ed., Washington, D.C.

[11.2] California Code of Regulations (CCR), Title 24, Part 3, California Electrical Code. ~~National Fire Protection Association, 2002, NFPA 70, "National Electrical Code (NEC)," Quincy, MA.~~

[11.3] American Petroleum Institute (API), 2012 (Errata January 2014) ~~1997~~, API Recommended Practice 500 (API RP 500), "Recommended Practice for Classification of Locations for Electrical Installations at Petroleum Facilities Classified as Class I, Division 1 and Division 2," 3rd ~~2nd~~ ed., Washington, D.C.

[11.4] National Fire Protection Association (NFPA), 2012 ~~1998~~, NFPA 496, "Standard for Purged and Pressurized Enclosures for Electrical Equipment," 2013 ed., Quincy, MA.

~~[11.5] 2 CCR 2341(f), Title 2, California Code of regulations, Section 2341(f).~~

[11.5~~6~~] National Fire Protection Association (NFPA)~~, 2010~~, NFPA 110, "Standard for Emergency and Standby Power Systems," Quincy, MA. For edition, see California Code of Regulations (CCR), Title 24, Part 2, Chapter 35 – Referenced Standards.

[11.6~~7~~] National Fire Protection Association (NFPA)~~, 2011~~, NFPA 111, "Standard on Stored Electrical Energy Emergency and Standby Power Systems," Quincy, MA. For edition, see California Code of Regulations (CCR), Title 24, Part 2, Chapter 35 – Referenced Standards.

[11.7] California Code of Regulations (CCR), Title 2, Division 3, Chapter 1, Article 5 – Marine Terminals Inspection and Monitoring (2 CCR 2300 et seq.)

~~[11.8] 2 CCR 2365, Title 2 California Code of Regulations, Section 2365.~~

[11.8~~9~~] Code of Federal Regulations (CFR), Title 33, Section 154.570 – Lighting (33 CFR 154.570) ~~33 CFR 154.570(d), Title 33 Code of Federal Regulations Section 154.570(d).~~

~~[11.10] 2 CCR 2370, Title 2 California Code of Regulations, Section 2370.~~

[11.9~~11~~] Oil Companies International Marine Forum (OCIMF), 1987, "Guide on Marine Terminal Fire Protection and Emergency Evacuation," 1st ed., Witherby, London.

[11.10~~2~~] American Petroleum Institute (API), 2012, API Standard 2350 ~~1996, API Recommended Practice 2350 (API RP 2350)~~, "Overfill Protection for Storage Tanks in Petroleum Facilities," 4th ~~2nd~~ ed., Washington, D.C.

[11.11~~3~~] Code of Federal Regulations (CFR), Title 33, Section 154.2102 – Facility Requirements for Vessel Liquid Overfill Protection (33 CFR 154.2102) ~~33 CFR 1 54.812, Title 33, Code of Federal Regulations, Section 154.812 - Facility Requirements for Vessel Liquid Overfill Protection.~~

~~[11.14] National Association of Corrosion Engineers (NACE), Standard Recommended Practice, 1994, RP01 76-1994 "Corrosion Control of Steel Fixed Offshore Platforms Associated with Petroleum Production," Houston, TX.~~

[11.12~~5~~] United Facilities Criteria (UFC), 2004 January 16, UFC 3-570-02N, "Electrical Engineering Cathodic Protection", ~~Department of Defense, 31 January 1990, Military Handbook, "Electrical Engineering Cathodic Protection," MIL-HDBK-1004/10,~~ Washington, D.C.

[11.13~~6~~] American Petroleum Institute (API), 2009 ~~2002~~, API 570, "Piping Inspection Code: In-service Inspection, Repair, and Alteration of Piping Systems," 3rd ~~2nd~~ ed., ~~October 1998 (February 2000 Addendum 1),~~ Washington, D.C.

~~*[11.17] 2 CCR 2341(d) and 2380, Title 2, California Code of Regulations, Sections 2341(d) and 2380.*~~

Authority: Sections <u>8750 through 8760</u> ~~8755 and 8757~~, Public Resources Code.

Reference: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

Notation
Authority: Sections 8750 through 8760, Public Resources Code.
References: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

DIVISION 12
SECTION 3112F
REQUIREMENTS SPECIFIC TO MARINE TERMINALS THAT TRANSFER LNG

12.1. ***3112F.1 Purpose and applicability.*** *Section 3112F provides minimum requirements specific to onshore marine terminals that transfer LNG. Sections 3101F through 3111F are also applicable, as appropriate. Offshore marine terminals that transfer LNG are subject to a case-by-case review and approval by the Division.*

12.2. ***3112F.2 Risk and Hazards Analyses.***

1. *Prior to LNG transfer at marine terminal, a hazards identification exercise shall be carried out to isolate potential internal and external events that may cause a spill and/or impact to public health, safety and the environment.*
2. *Hazards analysis shall consider every component, part of a structure, equipment item, and system, whose failure could cause a major accident, result in unacceptable incident escalation beyond the design basis, or adversely affect the potential for the passive and active systems to control or shutdown the facility. Safety Critical Components and Safety Critical Systems shall be identified.*
3. *Consequence models shall be developed for credible scenarios to identify Lower Flammability Limit (LFL) hazard regions. Release diameters shall include, at a minimum, 3mm, 10mm, and 50 mm sizes. Scenarios involving the marine loading arms shall consider a full bore release.*
4. *Consequence models shall develop radiant heat zones from jet and pool fires for the 25 kW/m^2, 12.5 kW/m^2, 5 kW/m^2 and 1.6 kW/m^2 thermal endpoints.*
5. *A Cryogenic Exposure Analysis (CEA) shall be conducted to identify equipment and structures susceptible to cryogenic spray and pool exposure due to LNG releases from different size holes.*
6. *A Facility Essential Systems Survivability Assessment (ESSA) shall be conducted to determine the survivability of the Safety Critical Components.*
7. *Impact on Safety Critical Components and Systems shall be mitigated.*

12.3. ***3112F.3 Specific berthing and mooring considerations.*** *In addition to the minimum design requirements for berthing and mooring in Sections 3103F, 3105F and 3107F of this code, the following shall be satisfied:*

1. *Wind force and moment coefficients for LNG vessels shall be used in accordance with Appendix A of OCIMF MEG 3 [12.1], as appropriate.*
2. *The limiting environmental criteria for which the LNG carrier may safely remain berthed at the terminal shall be determined using dynamic mooring analysis.*
3. *Real time monitoring and recording of environmental conditions including wind, current and waves shall be conducted to assist in mooring system management.*
4. *Vessel hull pressure shall be considered in fender analyses and design.*

12.4. ***3112F.4 Fire protection.*** *A Fire and Explosion Hazard Analysis (FEHA) for potential pool fires, jet fires, and flash fires, considering LNG releases from different size holes, as specified in Section 3112F.2, shall be conducted and result in recommendations regarding:*

1. *Type, quantity, and location of fire and gas detection devices to detect potential fires and/or gas releases in a specified time frame*
2. *Fire suppression coverage, including fixed and portable systems, and equipment necessary to allow the design scenarios to be mitigated and/or extinguished*
3. *Design application rates for required fire protection systems*
4. *Firefighting requirements, including an analysis of the capability of response by other facilities, USCG, and federal, state and local agencies*

Critical structural supports and equipment within the fire exposed areas identified in the FEHA shall be provided with passive fire protection designed for the duration identified in the analysis.

Emergency shutdown (ESD) systems shall be provided, in accordance with API RP 14C [12.2] and Section 12.3 of NFPA 59A [12.3], to shut down the flow of LNG to/from the terminal and shut down equipment whose continued operation could add to or prolong an emergency event.

The ESD system shall be of a failsafe design or shall be otherwise installed, located, or protected to minimize the possibility that it becomes inoperative in the event of an emergency or failure at the primary control system. ESD system components that may be exposed to fire effects shall be evaluated to confirm that the actuator operation will not be impaired.

12.5. ***3112F.5 LNG pipelines.***

1. *All pipe specified for use in cryogenic service shall be furnished in accordance with Paragraph 323.2.2A and Table A-1 of ASME B31.3 [12.4]. The extreme thickness of insulation on cryogenic piping shall be taken into consideration during piping design.*
2. *All piping materials, including gaskets and thread compounds, shall be selected appropriate to the range of temperatures to which subjected. Piping that may be exposed to the low temperature of LNG or to the heat of an ignited spill, during an emergency where such exposure could result in a failure of the piping, shall comply with at least one of the following:*
   - *(a) Made of material(s) that can withstand both the normal operating temperature and extreme temperature to which the piping may be subjected during the emergency*
   - *(b) Protected by insulation or other means to delay failure due to extreme temperatures until corrective action can be taken by the operator.*
   - *(c) Capable of being isolated and having the flow stopped where piping is exposed only to the heat of an ignited spill during the emergency*
3. *LNG pipelines shall be designed for cool-down with liquid nitrogen where the use of LNG is not possible.*
4. *All LNG drains should be located within a containment area or piped to a collection system or containment area.*
5. *LNG lines shall be analyzed for a start-up case where the top of the pipe is 90 degrees F warmer than the bottom of the pipe. The upward bowing of the pipe shall be limited to 1.25 inches.*

6. *Pipe supports, including any insulation systems used to support pipe whose stability is essential, shall be resistant to or protected against fire exposure, escaping cold liquid, or both if they are subject to such exposure.*

7. *Pipe supports for cold lines shall be designed to minimize excessive heat transfer, which can result in piping failure by ice formations or embrittlement of supporting steel. If icing up of piping and components is unavoidable, the weight of the accumulated ice shall be considered during piping and support design.*

8. *Valves shall comply with ASME B31.5 [12.5].*

9. *Cryogenic valves in liquid cryogenic service shall not be installed in vertical lines. Valves in liquid cryogenic service shall be installed in horizontal lines with the stem in the vertical position or at least 45 degrees vertically from the horizontal centerline of the pipe.*

10. *All cryogenic valves (except butterfly valves, check valves and globe valves) shall have a body cavity relief to the "safe" side of the valve. All cryogenic valves with a body cavity relief shall be marked on the exterior of the body with a letter "V" and an arrow pointing to the direction of the venting side.*

11. *Thermal relief valves shall be installed to protect the equipment and piping from over pressuring as a result of ambient heat input to blocked in LNG or other light hydrocarbon liquids.*

12. *Cryogenic subsea pipeline designs shall be qualified by a certifying agency, acceptable to the Division, in a qualification program that demonstrates that the system has been designed, fabricated and can function as intended with safeguards provided as determined to be necessary.*

12.6. *3112F.6 Mechanical components and systems.*

1. *The CEA analysis shall be used to recommend acceptable cryogenic exposure durations for Safety Critical Components to produce CEA drawings.*

2. *ESD system components, which are exposed to cryogenic effects, shall be evaluated to confirm that the actuators will not be impaired by the potential exposures, thereby preventing the components from failing to a safe position.*

3. *Critical structural supports and equipment within the cryogenically exposed areas shall be provided with cryogenic insulation. The cryogenic insulation and passive fire protection shall be designed for sufficient incident duration.*

4. *For marine loading arms in LNG service, ice formation on non-insolated arms and hoses must be taken into account. Mechanisms for venting, apex venting, purging and cool down of the marine loading arms shall be identified on the P&IDs.*

5. *Areas beneath marine arms shall have restricted access during and after product transfer, until there is no longer danger of falling ice.*

12.7. ***3112F.7 References.***

[12.1] Oil Companies International Marine Forum (OCIMF), 2008, "Mooring Equipment Guidelines (MEG3)," 3rd ed., London, England.

[12.2] American Petroleum Institute (API), 2001 (Reaffirmed 2007), API Recommended Practice 14C (API RP 14C), "Recommended Practice for Analysis, Design, Installation, and Testing of Basic Surface Safety Systems for Offshore Production Platforms," 7th ed., Washington, D.C.

[12.3] National Fire Protection Association (NFPA), 2012, NFPA 59A, "Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG)," 2013 ed., Quincy, MA.

[12.4] American Society of Mechanical Engineers (ASME), 2015, ASME B31.3-2014 (ASME B31.3), "Process Piping," New York.

[12.5] American Society of Mechanical Engineers (ASME), 2013, ASME B31.5-2013 (ASME B31.5), "Refrigeration Piping and Heat Transfer Components," New York.

Authority: Sections 8750 through 8760, Public Resources Code.

Reference: Sections 8750, 8751, 8755 and 8757, Public Resources Code.

Notation
Authority: Sections 8750 through 8760, Public Resources Code.
References: Sections 8750, 8751, 8755 and 8757, Public Resources Code.