Oregon Department of Environmental Quality

Seismic Vulnerability Assessment Forms

Form 4: Inspection and Assessment of Piers and Wharves (Marine Oil Terminals)

Per OAR 340-300-0003 (f)(D) Transloading facilities including wharves, piers, moorings and retaining structures:

This inspection/assessment follows the ASCE/COPRI "Waterfront Facilities Inspection and Assessment Standard Practice Manual," 2013 and Chapter 31F "Marine Oil Terminals" (California MOTEMS). Additional information, analyses, drawings or reports may be requested by DEQ.

Table 1. The assessment questions are based on the following:

ASCE/COPRI Standard Practice Manual Inspections	MOTEMS
Baseline inspection sections 2.1.5; 2.5	Section 3102F.1.5
Routine Inspection sections 2.1.2; 3.2.1 to 3.2.9	Table 31F-2-1
Structural Repair/Upgrade section 3.3	3102F.3.6.3
Post-Event Inspections sections 2.1.9 and 2.6.3	Section 3102F.4

1. **Baseline Inspection** - If "as built" or later modification drawings are not available, incomplete, or inaccurate, a baseline inspection is required. The level of detail must include structural member sizes, connection/reinforcing details, and any prior structural analysis. Structural drawings if not existent need to be prepared to markup deficiencies and also to use for the preliminary structural assessment to evaluate the continuing "fitness-for-purpose" of the terminal. The specific damage definitions for structural components (e.g. timber, steel, concrete) are provided in the documents/references above. For this initial baseline inspection, the Level I, II and III criteria apply.
2. **Routine Inspection** - The purpose of a Routine Inspection is to assess the general condition of the structure, assign a condition assessment rating, and make recommendations. Routine Inspections should be performed on a cyclical basis and represent a proactive approach to maintenance. The schedule for routine inspections, dependent on the previous results and environmental conditions and further explanations are provided in the references listed in table 1.
3. **Structural Repair or Upgrade Inspection -** This inspection should focus primarily on documentation of only those elements that are intended to be repaired or upgraded. For this reason, it is important to define specific repair criteria prior to executing the inspection. This inspection follows the two mentioned above and is after the comprehensive seismic analysis or design upgrades performed. With this final step in the initial inspection protocols, the structure(s) have been verified to comply with OAR 340-300 and remain within the performance limits with the seismic demand of the Design Level Earthquake (ASCE7). `
4. **Post-Event Inspections** – These inspections are focused on an earthquake of magnitude 5.0 or higher

that can damage the integrity of the facility. The intent of this inspection is to rapidly assess the structural stability and continue "fitness-for-purpose." Procedures are given PIANC WG 153 Section 16.3.4. DEQ should be notified as per OAR 340-300 including the following information:

- Brief description of the event
- Description of the damage observed,
- Operational status and/or restrictions, and
- The post-event inspection results.

Terminal:	Location:	Company:
Berthing System:		Date:

Part 1 – Pier Trestle Information (if applicable)	
Trestle Length (ft)	
Trestle Width (ft)	
Trestle Roadway Width (ft)	
Trestle Pipe way Width (ft)	
Trestle Minimum Pile Length, Mudline to Trestle (ft)	
Trestle Maximum Pile Length, Mudline to Trestle (ft)	
Maximum Allowable Uniform Vertical Load (psf)	
As-built Design Drawings Available?	
Structural Design Calculations Available?	

PART 2 – TRESTLE CONSTRUCTION INFORMATION (IF APPLICABLE)		
Element	**Material**	**Corrosion Protection (Describe)**
Piles		
Pilecaps		
Deck Beams		
Bracing		
Bulkhead/Retaining Wall		
Deck		

Part 3 – Main Loading Platform Information	
Loading Platform Length (ft)	
Loading Platform Width (ft)	
Loading Platform Minimum Pile Length, Mudline to Platform (ft)	
Loading Platform Maximum Pile Length, Mudline to Platform (ft)	
Maximum Allowable Uniform Vertical Load (psf)	
Maximum Design Impact Load (kips)	
Any tanks, concentrated loads, or areas of live load greater than a minimum	
As-built Design Drawings Available?	
Structural Design Calculations Available? (including fender/dolphin capacities)	

Main Loading Platform Construction Information		
Element	**Material**	**Corrosion Protection (Describe)**
Piles Batter piles		
Pilecaps		
Deck Beams		
Bracing		
Bulkhead/Retaining Wall		
Deck		

Marine Oil Terminal Information

Description	Yes	No	N/A	Comments	Deficiency ID (MOTXX)
Has an overall above water inspection of the terminal been performed, looking for gross damage or deterioration of structural items, or potentially dangerous situations?					MOT01
Condition of Steel Structures (Ref: ASCE/COPRI Section 2.5.2)					
Has an inspection been made of all above water steel components?					MOT02
Has an underwater inspection been made of all underwater steel components? If not, what is the date of the last underwater inspection?					MOT03
Did the underwater inspection include corrosion measurements using NDT methods?					MOT04
Does the above water portion of steel structures have a protective coating (paint or other)?					MOT05
If H-beams are present, have corrosion measurements of the web and flanges been taken at critical locations?					MOT06
Is there a cathodic protection system installed at this facility?					MOT07
If there is cathodic protection, has the system been inspected or the effectiveness of the system tested?					MOT08
If there is a sheet piling retaining wall, has it been inspected for corrosion, scour, and loss of fill? If there are tie-backs, have they been inspected, and if not, why not?					MOT09
Condition of Concrete Structures (Ref: ASCE/COPRI Section 2.5.3; Prestressed concrete Section 2.5.4)					
Has an inspection been made of all above water concrete components?					MOT10
If there is a concrete deck, has the underside of the deck been inspected?					MOT11

Description	Yes	No	N/A	Comments	Deficiency ID (MOTXX)
Has an underwater inspection been made of the piles?					MOT12
If not, what is the date of the last underwater inspection?					MOT13
Is there evidence of damage to the concrete structure from erosion or overstressing?					MOT14
Is there evidence of chemical damage to the concrete?					MOT15
Condition of Concrete Structures (continued)					
Is there evidence of corrosion of the reinforcing steel?					MOT16
Is the concrete protected using surface coatings or linings, if so, what is the condition?					MOT17
Condition of Timber Structures (Ref: ASCE/COPRI Section 2.5.1)					
Has an inspection been made of all above-water timber components?					MOT18
Is there any cracking or other surface damage in the above-water timber structural members?					MOT19
Has an underwater inspection been made of the piles?					MOT20
If not, what is the date of the last underwater inspection?					MOT21
Is there any evidence of marine borer damage?					MOT22
Are the piles protected with plastic or other type of coating?					MOT23
If so, does the protective layer appear to be effective?					MOT24
If there are bracing members, have the bracing connections been inspected?					MOT25

Underwater Inspection Levels of Effort					
Level	**Purpose**	**Detectable Defects**			
		Steel	**Concrete**	**Timber**	**Composite**
I	General visual/tactile inspection to confirm as- built condition and detect severe damage	Extensive corrosion, holes Severe mechanical damage	Major spalling and cracking Severe reinforcement corrosion Broken piles	Major loss of section Broken piles and bracings Severe abrasion or marine borer attack	Permanent deformation Broken piles Major cracking or mechanical damage
II	To detect surface defects normally obscured by marine growth	Moderate mechanical damage Corrosion pitting and loss of section	Surface cracking and spalling Rust staining Exposed reinforcing steel and/or prestressing strands	External pile damage due to marine borers Splintered piles Loss of bolts and fasteners Rot or insect infestation	Cracking Delamination Material degradation
III	To detect hidden or interior damage, evaluate loss of cross-sectional area, or evaluate material homogeneity	Thickness of material Electrical potentials for cathodic protection	Location of reinforcing steel Beginning of corrosion of reinforcing steel Internal voids Change in material strength	Internal damage due to marine borers (internal voids) Decrease in material strength	N/A

Scope of Underwater Inspections

Level		Sample Size and Methodology[1, 2]							
		Steel		**Concrete**		**Timber**		**Composite**	**Slope Protection/ Channel Bottom or Mudline-Scour**
		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%
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%

The stated sample size may be reduced in the case of large structures where statistically representative sampling can be demonstrated to the Division in accordance with these standards. The sampling plan must be representative of all areas and component types (i.e. approach trestles, pier/wharf, dolphins, inboard, outboard, batter, vertical, concrete, steel, timber, etc.). Any reduced sampling plan proposed to the Division must include the Level I inspection of all piles around the perimeter of the facility where vessels may berth or where debris may impact or accumulate. If the reduced sampling plan proposes to conduct less than 100 percent Level I effort, then the results of the inspection must be carefully monitored. If significant deterioration is observed on any component, which could reasonably be expected to be present on additional components, and which could have a detrimental effect on the load bearing capacity of the structure either locally or globally, then the inspection scope shall be increased to include a 100 percent Level I effort. See reference [2.2].
The minimum inspection sampling size for small structures shall include at least two components. LF = Linear Feet; SF = Square Feet; N/A = Not Applicable

Standard Pile Inspection Record

(Repeat sheet, as necessary)

Terminal:	Location:	Company:	Divers:
Berth No.:		Date:	
Time of Day:	Tide:	Pile Type (Bearing, Batter, Sheet):	Pile Material:

Location		**Level II Insp**	**Level III Insp**	**Water Depth**	**Pile Condition Rating**						**Comments**
Bent	Pile				NI	ND	MN	MD	MJ	SV	

ADDITIONAL COMMENTS:

CONDITION RATING LEGEND:
NI = Not inspected, inaccessible ND = No Deterioration/Damage MN = Minor Deterioration/Damage
MD = Moderate Deterioration/Damage MJ = Major Deterioration/Damage
SV = Severe Deterioration/Damage

Standard Component Inspection Record

(repeat sheet, as necessary)

Terminal:	Location:	Company:	Divers:
Berth No.:		Date:	
Time of Day:	Tide:	Component Type: Beams	Component Material: Steel

Component ID	Location	Component Condition Rating						Comments
		NI	ND	MN	MD	MJ	SV	

ADDITIONAL COMMENTS:

CONDITION RATING LEGEND:
NI = Not inspected, inaccessible ND = No Deterioration/Damage MN = Minor Deterioration/Damage
MD = Moderate Deterioration/Damage MJ = Major Deterioration/Damage
SV = Severe Deterioration/Damage

Seismic Analysis and Structural Performance of Non-structural components

Nonstructural Components	Response/Comments	
Has a laydown pattern with equipment loads been provided of the wharf/pier deck?		MOT26
What assumptions have been made for the pipeline trestle and on the wharf/pier deck?		MOT27
Has the anchorage, flexibility and seismically-induced interaction of these components been considered?		MOT28

For the Seismic Analysis of Wharfs and Piers

- For geriatric structural properties, see MOTEMS Tables 31F-7-1 and 2. For unknown exact properties, use the "knowledge factor" of MOTEMS 3107.2.1.2
- For allowable performance-based strain limits for the Design Earthquake, use Port of Long Beach, "POLB Wharf Design Criteria," Version 4.0, Section 4.4 or ASCE61-14 Table 3-3 for life safety protection.
- Per DEQ 340-300-0003, (f) using codes/standards and ASCE7 to assess "transloading facilities including wharves, piers, moorings and retaining structures".
- Per DEQ 340-300-0004 (a) Reconstruction, replacement, etc. to achieve the performance objective and meet the specifications of OAR 340-300-0003…" Meeting the requirements of Risk Category IV design of new structures satisfies the intent of this rule.
- Loading combinations ("Seismic Design of Piers and Wharves," ASCE/COPRI Standard, ASCE/COPRI 61-14).

  Horizontal: (1 + 0.50 PGA) D + 0.10L + H + E

  Vertical: Substitute 0.50 PGA FOR PGA D = Dead Load

  PGA = Peak Ground Motion

  L = Live Load

  H = Soil Pressure Loads

  E = Horizontal Seismic Loads

Overall Condition Rating (ACR)	
Overall Condition Rating (ACR) (Check the appropriate box on the left)	**Descriptions of Structural Systems**
Good (6)	No problems or only minor problems noted. Structural elements may show very minor deterioration, but no overstressing observed. The capacity of the structure meets the requirements of this standard. The structure should be considered fit-for-purpose. No repairs or upgrades are required.
Satisfactory (5)	Limited minor to moderate defects or deterioration observed, but no overstressing observed. The capacity of the structure meets the requirements of this standard. The structure should be considered fit-for-purpose. No repairs or upgrades are required.
Fair (4)	All primary structural elements are sound; but minor to moderate defects or deterioration observed. Localized areas of moderate to advanced deterioration may be present, but do not significantly reduce the load bearing capacity of the structure. The capacity of the structure is no more than 15 percent below the structural requirements of this standard, as determined from an engineering evaluation. The structure should be considered as marginal. Repair and/or upgrade measures may be required to remain operational. Facility may remain operational provided a plan and schedule for remedial action is presented to DEQ.
Poor (3)	Advanced deterioration or overstressing observed on widespread portions of the structure but does not significantly reduce the load bearing capacity of the structure. The capacity of the structure is no more than 25 percent below the structural requirements of this standard, as determined from an engineering evaluation. The structure is not fit-for-purpose. Repair and/or upgrade measures may be required to remain operational. The facility may be allowed to remain operational on a restricted or contingency basis until the deficiencies are corrected, provided a plan and schedule for such work is presented to DEQ. .
Serious (2)	Advanced deterioration, overstressing or breakage may have significantly affected the load bearing capacity of primary structural components. Local failures are possible and loading restrictions may be necessary. The capacity of the structure is more than 25 percent lower than the structural requirements of this standard, as determined from an engineering evaluation. The structure is not fit-for-purpose. Repairs and/or upgrade measures may be required to remain operational. The facility may be allowed to remain operational on a restricted basis until the deficiencies are corrected, provided a plan and schedule for such work is presented to and accepted by DEQ.
Critical (1)	Very advanced deterioration, overstressing or breakage has resulted in localized failure(s) of primary structural components. More widespread failures are possible or likely to occur and load restrictions should be implemented as necessary. The capacity of the structure is critically deficient relative to the structural requirements of this standard. The structure is not fit-for-purpose. The facility shall cease operations until deficiencies are corrected and accepted by DEQ.

Structural Follow-up Actions Ref: MOTEMS, Table 31F-2-7 and ASCE/COPRI Waterfront Facilities and Assessment, Table 2-16	
Follow-up Action	**Description**
Emergency Action	Specified whenever a condition that poses an immediate threat to public health, safety or the environment is observed. The appropriate owner representatives should be contacted immediately. Emergency actions may consist of barricading or closing all or portions of the structure placing load restrictions or unloading portions of the structure.
Engineering Evaluation	Specified whenever significant damage or defects are encountered that require a structural investigation or evaluation to quantify the structural capacity, determine if repairs are required, or to determine what method of repair is appropriate. The engineering evaluation should consider the actual or anticipated loads that are or will be imposed on the structure.
Structural Repair or Upgrade Design Inspection	Specified whenever damage or defects requiring repair are observed. The repair design inspection is performed to the level of detail necessary to prepare appropriate repair plans, specifications and estimates.
Upgrade Design and Implementation	Specified whenever the structural system requires upgrading to comply with the requirements of these standards and current applicable codes.
Special Inspection	Typically specified to determine the cause or significance of non-typical deterioration, usually before designing repairs. Special testing, laboratory analysis, monitoring or investigation using non-standard equipment or techniques are typically required.
Develop and Implement Repair Plans	Specified when the Repair Design Inspection and required Special Inspections have been completed. Indicates that field data has been collected and the structure is ready to have repair documents prepared. This must be approved by DEQ before construction.
No Action	Specified when no further action is necessary until the next routine inspection is scheduled.

Intervals Between Routine (Future) Inspections of Marine Terminals

Maximum interval between underwater inspections (years)[1] Ref: ASCE/COPRI Standard Practice Manual						
Condition Rating from Previous Inspection	**Construction material**				**Channel Bottom or Mudline – Scour[4]**	
	Unwrapped Timber or Unprotected Steel (no coating or cathodic protection)[4]		**Concrete, Wrapped Timber, Protected Steel or Composite Materials (FRP, plastic, etc.)[4]**			
	Benign[2] Environment	**Aggressive[3] Environment**	**Benign[2] Environment**	**Aggressive[3] Environment**	**Benign[2] Environment**	**Aggressive[3] Environment**
6 (Good)	6	6	6	6	6	5
5 (Satisfactory)	6	4	6	6	6	6
4 (Fair)	5	3	5	5	6	6
3 (Poor)	4	3	4	4	6	6
2 (Serious)	2	1	2	2	2	2
1 (Critical)	N/A[5]	N/A[5]	N/A[5]	N/A[5]	N/A[5]	N/A[5]

The maximum interval between Underwater Audit Inspections shall be reduced as appropriate based on the extent of deterioration observed on a structure, the rate of further anticipated deterioration, or other factors.

Benign environments include fresh water and maximum current velocities less than 0.75 knots for the majority of the days in a calendar year

Aggressive environments include brackish or salt water, polluted water, or waters with current velocities greater than 0.75 knots for the majority of the days in the calendar year.

For most structures, two maximum intervals will be shown in this table, one for the assessment of construction material (timber, concrete, steel, etc.) and one for scour (last 2 columns). The shorter interval of the two should dictate the maximum interval used.

MOTs rated “Critical” will not be operational; and Emergency Action shall be required

Post-earthquake damage assessment per all facility components

(Tanks, Berms, Pipelines, Marine Terminals, etc.)

A separate assessment is needed for each of the facility's components

(Assessment triggered by any measurable ground shaking on site or as directed by DEQ; Note that a distant event, without any ground shaking could still impose tank sloshing)

Post-event rating (Ref: Table 2-15, ASCE/COPRI; Table 31F-2-9, MOTEMS)		
Rating	**Summary of Damage**	**Remedial Actions**
A	No significant event-induced damage observed.	No further action required. The berthing system may continue operations.
B	Minor to moderate event-induced damage observed but all primary structural elements and electrical/mechanical systems are sound.	Repairs or mitigation may be required to remain operational. The berthing system may continue operations.
C	Moderate to major event-induced damage observed which may have significantly affected the load bearing capacity of primary structural elements or the functionality of key electrical/mechanical systems.	Repairs or mitigation may be necessary to resume or remain operational. The berthing system may be allowed to resume limited operations.
D	Major event-induced damage has resulted in localized or widespread failure of primary structural components; or the functionality of key electrical/mechanical systems has been significantly affected. Additional failures are possible or likely to occur.	The berthing system may not resume operations until the deficiencies are corrected.

List of Attachments and Reports

	Reference	Description or Title
1	Drawing set xxx	Mark-up structural drawings showing all deficiencies
2	Structural Analysis yyy	Historical structural analysis (if available) and preliminary assessment of continuing usage of the terminal based on results from the baseline inspection and estimated “fitness-for-purpose.”
3	Post Baseline Inspection	Spreadsheets for each set of damaged components (e.g. piles, decks, bracing, etc.)
4		
5		
6		

Contact

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