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Navigating a MOTEMS Audit

by

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Abstract:

This paper discusses the audit process and lessons learned during a MOTEMS Audit. The author and his colleagues have submitted four audits of high risk facilities and are currently working on three medium risk facilities. They have compiled a timeline for a successful audit completion and have summarized some of their lessons learned. The audit process includes: data collection, surveys, demand and capacity comparisons for operating and seismic analyses, document preparation, and audit submittal. The paper discusses estimated durations for these tasks and the intermediate milestones that need to be met for a successful audit submittal. The lessons learned portion highlights some pitfalls to avoid for a smoother audit process. The paper discusses: component vs. global CARs, unexpected deficiencies, mitigation and operations; and communication between operator, regulator, and audit team.

Introduction:

Ben C. Gerwick, Inc has submitted four MOTEMS Audits for High Risk Terminals to the California State Lands Commission (CSLC) for review and comment. We submitted the first two audits to State Lands and have received comments, which are presently being used to develop responses to CSLC Staff. This paper includes the MOTEMS Audit Process and the Lessons Learned, which can be used by medium and low risk terminals for their Audit Submittals to State Lands.

The Audit Process:

The Marine Oil Terminal (MOT) is the responsible party for the coordination and completion of the Initial Audit to be submitted to State Lands. The MOT will assign a representative to coordinate between the Terminal Staff, Audit Team, and CSLC Staff. The Terminal Representative will contract with the Audit Team, which is comprised of various engineering disciplines necessary to complete the Audit in accordance with the requirements prescribed in Chapter 31F of the California Building Code.

The Audit Process consists of four primary phases:

1. Information Gathering and Inspections
2. Operational and Seismic Analyses
3. Checklists, Missing Information, Deficiency Tables Development
4. Executive Summary and Audit Submittal

The Audit Process phases are discussed below.

Information Gathering and Inspections

The Information and Data Gathering Stage includes review of MOT drawing archives, MOT report archives, above and underwater inspections, geotechnical inspections, fire system inspections, piping inspections, equipment inspections, and electrical inspections.

MOTEMS has specific requirements for as-built drawings and specifications, condition surveys, and geotechnical information. The available drawings and reports may be useful for the Audit, but the dates should be reviewed for consistency with present conditions. As-built drawings and specifications may be available in newer (circa 1970) structures, but are rare in older (circa 1940) terminals. Condition Surveys for structure, piping, and equipment, may also be useful for the Audit, but the inspection dates may not meet MOTEMS requirements. Hydrographic and Topographic Surveys should be consistent with present conditions at the terminal. The survey information will be used in both the structural and geotechnical analyses.

The Underwater Inspections Team Leader is required to be a certified diver and licensed engineer. The PE Diver will direct the underwater inspections and is required to perform 25% of the inspections. Our surveys included a pre-dive meeting that discussed the most important or heavily loaded piles. The heavily loaded piles are typically found beneath loading arms, gangway towers, control rooms, mooring hardware and heavy pieces of equipment. On large structures with significant (>20) piles, we have marked bents and rows to allow diver orientation during the inspections. Pile and bent marking has also proven to be beneficial for future surveys and repairs to ensure that the correct piles are being repaired.

The available geotechnical information will be used to determine the extent of additional boring and cone-penetrometer testing (CPT) required for MOTEMS compliance. MOTEMS requires that borings be taken to a depth of 100-ft, or bedrock. Marine borings can be an expensive item due to barge mobilization costs, so the availability of existing geotechnical information can provide a significant savings to the MOT. If new mooring, breasting, or loading platform structures may potentially be required for mitigation measures, then the actual boring locations should be near the proposed structure locations. The geotechnical engineer is interested in both longitudinal (along the berth) and transverse soil profiles to determine embankment stability. The soil parameters are needed for both structural and geotechnical analyses.

Operational and Seismic Analyses

The structure capacity and demand are determined using MOTEMS prescribed methods. The structure capacity is based on known material properties and condition surveys. The demand is a function of the calculated loading per MOTEMS Operational and Seismic Chapters. If the capacity is greater than, or equal to the demand, then the structure is “fit-for-purpose” and can safely and adequately resist the applied loading.

The operational demands are the day-to-day events at the terminal. These loads include dead, live, berthing, and mooring loads. Since the operational demands are more likely to occur than the seismic

loads, the operational demands are expected to be addressed with greater urgency by State Lands in regards to possible mitigation measures. If a terminal is found to be “not-fit-for-purpose,” then immediate action should be expected to allow for restricted operations. This may include analysis to determine acceptable operational envelopes for the present conditions and/or immediate repairs.

The seismic demands are the probable once-in-a-lifetime event at the terminal. These loads are “expected” to occur once every 72-years (Level 1 Earthquake) or 475-years (Level 2 Earthquake) for “High Risk Terminals.” Although the return periods for the earthquakes may seem far off, the loads could occur at any time and are consistent with major Port design criteria on the West Coast.

The seismic analyses can include both structural (inertial) and kinematic (soil movement) loading on the structure. These loads tend to be uncoupled, but may have a large impact on the structure and associated piping.

Checklists, Missing Information, and Deficiency Tables

The “Draft Audit Manual” is available on-line from the California State Lands Commission Marine Facilities Division website. The Audit Manual is a good starting point for the sample questions and checklists to follow in developing the Audit. The missing information tables are used to highlight information, analyses, or surveys that are not presently available, but will be required to complete the Audit. The results of the operational and seismic analyses and assessments will be used for the completion of the Deficiency Tables. The Checklists, Missing Information, and Deficiency Tables are used for the development of the Executive Summary and subsequent Audit Submittal.

Executive Summary and Audit Submittal

The Executive Summary includes a brief description of the terminal, Structural Condition Assessment Ratings (CARs) Table, Component Remedial Action Plan (RAPs), and Path Forward. The Path Forward addresses the deficiencies and outlines the repair schedules. The Path Forward requires input from the terminal operator, owner, and corporate financial decision makers. The schedule development may take longer than anticipated due to associated construction costs for potential upgrades or replacements. Two copies of the MOT Audit and CDs will be required for submittal to CSLC Staff.

Lessons Learned:

Since Ben C. Gerwick, Inc. is a civil/structural engineering firm, most of our lessons learned will relate to Sections 2 through 7 of the MOTEMS Audit. The primary lessons learned relate to the following five topics:

1. Planning and Scheduling
2. Mitigation May Be Required
3. Testing is Knowledge
4. MOTEMS Modifications
5. Communication

The lessons learned on the four High Risk terminals submitted are intended to help the Moderate and Low Risk terminal operators avoid pitfalls or potential delays during the course of their Audits and eventual submittal. The lessons learned are summarized below:

Planning and Scheduling

We have completed Audits in six to twelve months. The shorter duration usually involved newer or smaller structures with fewer deficiencies that required mitigation. Twelve months is a recommended duration to complete an Audit since it allows for longer inspection windows, more internal review, coordination with operators, coordination with corporate planners, coordination with CSLC staff, and refinement of path forward prior to the Audit submittal.

Ideal underwater inspection conditions occurs in Hawaii; clear water, slow currents, and lots of sunshine. Some terminals are located along rivers or estuaries with river run-off that results in low visibility and fast currents (> 1 knot). The currents, visibility, and weather will affect the available inspection windows for both divers and below deck inspections.

Ship schedules will also affect the available inspection windows. Due to safety procedures, small inspection craft and personnel may not be allowed within 100 feet of the manifold area or vessel intakes to perform inspections. This precaution prevents divers from inadvertently being caught in the ship intake or sparking from a small craft. The inspection team should plan to coordinate closely with terminal and Captain to avoid potential delays in the inspection process. We recommend that the inspection teams start with the most active berth and work from there, or plan inspections during scheduled terminal maintenance periods.

Geotechnical Investigations should also be started early to allow for additional sampling, if needed. The soil parameters are needed for both operational and seismic analyses. Geotechnical Hazard Analyses may require additional time and samples to confirm or refine preliminary findings. One terminal deficiency included lateral spreading during a Level 1 seismic event that would impose high lateral loads on the existing piling. By additional Cone Pentrometer Testing (CPT), the unit soil weight was reduced, which resulted in lower pile loads.

The Audit Team and Operator should schedule bi-monthly meetings to discuss progress and potential deficiencies. Operational deficiencies should be discussed immediately to allow for operating and possible repair mitigation measures. The magnitude of the deficiency will formulate the Path Forward in the Executive Summary. In some cases, the deficiency may require an upgraded berthing system, or possibly a new loading platform. These major cost items will require input and approval from terminal and corporate management.

The Audit Team and Operator should plan to schedule a meeting with California State Lands Commission (CSLC) staff at critical decision points during the Audit. One critical point may be after preliminary inspections and proposed intermediate repairs. After the preliminary checklists and deficiency tables are completed, then schedule a meeting with CSLC staff for the initial Audit walk-down and to discuss inspection findings.

Allow for adequate time to allow for document reproduction and shipping. CSLC requires two (2) copies of both hardcopy and digital records for their review and records. Some Audits included six (6) 4-in wide volumes of Audit Material. The printing, checking, compiling, and shipping of Audit material will require approximately one month.

Mitigation May Be Required

Audits have been performed on structures constructed in the 1950s or earlier, with some improvements or modifications since original construction. Structures constructed in the 1950s were typically designed for mooring and berthing of T2 tankers. Seismic or earthquake forces were estimated to be between 5 and 10% of the structure gravity loads. Generally, structures were designed in the transverse direction for berthing a tanker and longitudinal direction for mooring and seismic loads. However, the tanker sizes have increased approximately five fold from T2 tankers (20,000 DWT) to Aframax (105,000 DWT) tankers. The seismic design forces have increased more than ten times to approximately 100% of the structure gravity loads. These dramatic increases in applied loads can lead to demands (loads) being substantially greater than the original structure capacity (strength).

Older structures have experienced wear and tear and larger vessels calling at the berths. This affects both fender and mooring systems and hardware. Since the structure capacities are less than the new demands, the operator/owner can expect that there may be deficiencies that will require mitigation. Mitigation could include both passive and active measures. Passive measures require re-analysis and assessment by reducing vessel displacement, vessel approach velocity, vessel windage areas, and vessel size. Active measures require immediate repairs to allow damaged members to return to original, or better, capacities. Some older terminals may require both a passive and active response to mitigate deficiencies.

During the course of an Audit, incidents (earthquakes, passing vessel, mooring line handling, and vessel impact …) can occur at the terminal. These incidents require Event Reports and Emergency Repairs per MOTEMS. The Audit team is the most qualified to respond the event and develop repairs necessary to restore operations; however, the strain on resources can delay the planned completion of the audit.

Estimating for intermediate or emergency repair design and construction costs is difficult until the extent of the damage can be determined. The design and repair costs can be significant, but are usually small compared to a terminal that cannot transfer product. The terminal operator and owner should plan to have some allowance for as-needed engineering and construction services to mitigate damage caused by daily wear-and-tear or a specific event.

Testing is Knowledge

MOTEMS requires the use of a knowledge factor (capacity reduction factor) to be applied for demand to capacity calculations. Older terminals generally do not have specifications or material test records in their archives. Without the proper certification, a 25% reduction factor is applied to the material

capacities, similar to FEMA requirements. The 25% reduction can result in a significant penalty for structures that are now required to resist greater demands as discussed above. However, testing can prove beneficial for marginal (Fair or better) structures.

Two terminals constructed in the 1920s used coiled steel springs that showed rust and pre-compression. The continuous fender system was originally designed for T2 tankers and now was required to resist Panamax tankers. On paper, the fender system was overstressed, but with testing of the spring assembly the fenders had adequate capacity to resist the tanker berthing loads when combined with a velocity monitoring system.

An emergency repair to an existing trestle required timber pile bolt connection testing to confirm that it could adequately support the existing piping. The age of the timber and bolt pattern resulted in low calculated capacities using Timber National Design Specifications and MOTEMS knowledge factor. However, the proposed repair was tested and we could not fail the connection using much higher than the calculated demands. CSLC reviewed the proposed details and test results and allowed the terminal to be re-opened for operations.

MOTEMS Modifications

During the course of the Audit, we encountered a few items that should be clarified to avoid misunderstandings. The proposed modifications are listed below:

1. Clarify the Difference between Element and Global Condition Assessment Ratios (CARs). The assignment of the global CAR relates to the structure's capacity to resist actual operating or seismic demands per Table 31F-2-5. The assignment of an element CAR is actually not an assessment for load carrying capacity, but rather a description of the actual damage or loss of section. The element CAR should be renamed to either a Damage Assessment Ratio (DAR) or Condition Survey Rating (CSR) per the standards used in the Draft Audit or ASCE Underwater Inspection.

2. Eliminate the above and below water inspection designation as +3-ft. The specific structural element affected by +3-ft is either a pile or seawall. The assignment of a below water and above water damage value is irrelevant since the structural element is only as capable as its weakest portion. The piles and seawalls should be inspected from mudline to bottom of deck with one condition rating.

3. The Deficiency Tables should add a column for Date Completed. The checklists lead to the deficiency tables, which lead to the executive summary tables and subsequently the path forward. Adding a column for Date Completed on the Deficiency Tables will allow the Terminal Operator to amend the Deficiency Tables as deficiencies are repaired. As CSLC staff performs a bi-annual review, the terminal operator can provide the deficiency tables for State Lands and operator walk through and agreement. This addition will improve monitoring and save the terminal and CSLC staff time during the bi-annual review.

4. The Executive Summary should be as concise as possible. Due to size and volumes of material, the entire Audit will be read by only a handful of people. The executive summary may

be forwarded to corporate offices for review and comment. In order to trim the size of the executive summary, we expanded the executive summary tables to include short descriptions of the deficiency, proposed mitigation, and schedule for mitigation completion. A short executive summary allows the summary to be read in ten to fifteen minutes. Our audience for the executive summary was the local terminal wharf manager's supervisor and the refinery manager.

The proposed MOTEMS modifications will lead to fewer misunderstandings between owner, operator, engineer, and regulator. These modifications should improve understanding and communication for the various parties involved in the Audit Process.

Communication

The Terminal Representative is the most important person for a successful audit. The Terminal Representative needs to coordinate between the Terminal Management Staff, the Audit Team, and the CSLC Staff. The Terminal Representative will have direct contact with structural, geotechnical, mechanical, piping, electrical, and fire safety engineers on the Audit Team. The Terminal Representative must also have contact with the Terminal Staff, which includes wharfingers, process engineers, accountants, and planners. State Lands Staff will typically contact the Terminal Representative to discuss audit progress and possible deficiencies. The Terminal Representative must be able to communicate effectively with a wide variety of professionals in order to avoid potential problems and audit submittal delays.

Although the Terminal Representative is the conduit between the Terminal and CSLC Staff, sometimes it is advisable for the operator to allow informal discussion between Audit team members and CSLC staff to clarify potential misunderstandings of MOTEMS requirements. We have successfully saved both time and money by communicating with CSLC staff to clarify direction and application of MOTEMS requirements. CSLC staff has then met with the Audit Team and the Terminal Representative to clarify alternative measures that result in savings to the terminal. CSLC staff is available to discuss regulations and alternative measures, provided they maintain the integrity of the facility and safety of the public and environment.

Lessons Learned from the High Risk Audits completed can be applied to the next round of Moderate Risk Audits due in February 2010.

Summary:

- Medium and Low Risk Marine Oil Terminals should review the requirements of a MOTEMS Audit Report as outlined in the California Building Code. However, the Draft MOTEMS Audit Manual available on line and is a recommended guideline for development of a future Audit. The checklists are especially useful for development of missing information and deficiency tables.

- Twelve months is a recommended duration to complete a MOTEMS Audit. Although Audits have been completed in less time, unexpected events may occur that will require attention from the audit team to maintain operations.

- Expect mitigation requirements in older structures. Marine terminals are typically designed with an expected life of 25 years. Older structures may have some damage over time due to age or use by larger than original design conditions. If the terminal is older than 25 years, then it would be reasonable to expect some damage or deficiency that will require mitigation to remain operational.

- Testing can be beneficial for structural members with marginal capacities. The MOTEMS knowledge factor may reduce the structural capacity by 25%. Testing can eliminate the knowledge factor reduction and allow a marginal system to exceed the structure demands from operations, berthing, mooring, and earthquakes.

- The Marine Oil Terminal Audit Project Manager should have good communication skills since he will be coordinating between several different engineering disciplines, terminal staff, refinery management, and CSLC staff. We have been fortunate in our recent Audits to have good MOT Audit Project Managers and Terminal Representatives.

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