Valdez Marine Terminal
Crude Oil Storage Tank 5

Report to:

Prince William Sound
Regional Citizens' Advisory Council
(PWSRCAC)

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1. Introduction

This report responds to the Prince William Sound Regional Citizens' Advisory Council's (PWSRCAC's) request for a review of Valdez Marine Terminal (VMT) Crude Oil Storage Tank 5 records.

The VMT Oil Discharge Prevention and Contingency Plan (ODPCP) requires the next Tank 5 internal inspection to be completed in 2012. Alyeska Pipeline Service Company (APSC) has submitted a request to the Alaska Department of Environmental Conservation (ADEC) to defer the inspection to 2014.

This report provides a summary of findings and recommendations based on the records reviewed.

2. Data Used in Analysis

Data used in this analysis are listed below:

- APSC, 2001 Tank 5, 10-year Internal Inspection Report, a six page APSC memo prepared by Kelly Lee (APSC) for Tom Stokes (APSC) that summarizes the inspection; memo dated January 29, 2003.
- 2002 APSC Civil and Corrosion Annual Monitoring Report APSC Government Letter No. 03-20011, that summarizes the Tank 5 work completed in 2001 and 2002, among other topics, dated July 2, 2003.
- APSC, 2001 Tank 5, 10-year Internal Inspection Report, a six page APSC memo prepared by William Mott (APSC) for Hally Cooper (APSC) that summarizes the inspection; memo dated September 21, 2011. This memo is title "Revised Corrosion Report 54-TK-5," it revised the earlier 2003 memo prepared by Kelly Lee.
- APSC, 2007 Tank 5, 5-year External Inspection Report, a 13 page APSC report prepared by Steven Hanson (APSC) that summarizes data collected by Robert Dale Long Jr. (APSC); report dated August 31, 2007.
- Valdez Marine Terminal Tank 5, Alleged Integrity Concerns Preliminary Investigation, report prepared by Harvey Consulting, LLC (HCLLC) for PWSRCAC, March 13, 2007.
- APSC letter to ADEC regarding VMT Crude Oil Storage Tank 5 Internal Inspection Waiver Request, Government Letter No. 23771, October 20, 2011.

3. Tank 5 Inspection History

The last Tank 5 internal inspection was completed in 2001. The tank floor was replaced in 2002 as a result of the internal inspection findings that confirmed the tank floor was significantly corroded. In addition to the tank floor, the inspection examined the annular ring, shell, column, and roof. The inspection was completed by an API Certified Inspector.

Complaints were filed under APSC's Employee Concerns Program about the 2001 Tank 5 inspection and the 2002 Tank 5 floor replacement. APSC, ADEC, and JPO investigated the complaints, and authorized that Tank 5 be returned to service in 2002.

On July 2, 2003 APSC provided JPO with its 2002 Civil and Corrosion Annual Monitoring Report that summarized the Tank 5 work completed in 2001 and 2002.[1]

> *"Crude Tank 5 of the Crude Storage System was drained down and opened for entry in 2001. Inspection of the roof and shell revealed no substantial corrosion. The floor was given a magnetic flux examination and numerous locations were identified for further UT inspection. Further UT inspection revealed corrosion rates sufficient to justify replacing 100% of the floor plate and installing a new grid-type soil-side cathodic protection system underneath. The new cathodic protection grid system consisted of ½" mixed metal oxide ribbon on a 2.5 ft. spacing. The system was commissioned in December 2002. The new tank floor was coated and the tank was returned to service."*

Employees who filed the complaints did not agree that Tank 5 issues were adequately resolved. They appealed to Chuck Hamel for assistance. Chuck Hamel represented the employees and raised a whistleblower complaint in 2006.

In 2006, PWSRCAC requested that HCLLC review Tank 5 records and examine the Employee Concerns Program allegations. The HCLLC report examined whether the allegations could be substantiated, and whether APSC, ADEC and JPO had thoroughly investigated and resolved the concerns. HCLLC's Tank 5 review commenced the fall of 2006. An initial report was filed on December 17, 2006. It was later supplemented on March 13, 2007, when additional information was provided for review.

HCLLC's March 2007 report is attached (Attachment No. 1). HCLLC's report confirmed:

1. An complete internal roof inspection was not completed despite the tank inspector's recommendation for a more thorough internal roof inspection; APSC denied the inspector access to equipment to reach the roof and time to complete the additional inspection work.
2. The tank inspector requested construction and repair records on Tank 5; these records were not made available to the inspector.
3. The annular plate was not inspected after back-gouging.
4. Shell inspection was not completed in accordance with tank inspector's recommendations and equipment and inspection time was denied; therefore, the shell inspection was incomplete.
5. There was no nameplate on the tank.
6. The roof support column inspection was incomplete.

Allegations that could not be fully evaluated by HCLLC due to the lack of data include:

1. Material used to replace the floor was substandard;
2. Floor bottom plates were improperly tested;
3. Floor plates were improperly welded to the annular ring;
4. There was no weld preheat on the door cut in tank wall to repair tank floor; and
5. The joint design on the door was improperly approved.

[1] APSC Government Letter No. 03-20011.

Allegations that proved unsubstantiated include:

1. Annular plate was not 100% inspected. HCLLC confirmed that this testing was completed as required.

HCLLC recommended that PWSRCAC request additional records and consult with a welding expert to evaluate the remaining six allegations. If additional records could not be obtained and expert review could not be accomplished in a timely manner, HCLLC recommended an accelerated inspection schedule be considered for Tank 5.

As part of this 2012 review, HCLLC requested a copy of any additional Tank 5 records obtained by PWSRCAC and the results of any additional work completed on Tank 5. PWSRCAC provided a copy of the 2007 Tank 5 external inspection report prepared by APSC.

The 2007 Tank 5 external inspection was completed by Robert Dale Long, Jr. on August 31, 2007. Long is listed in the report as the "inspector" and a Level II APSC Technician. There is no information in the report to verify whether Long is an API 653 inspector. API 653 requires inspections to be performed by a certified inspector. To become certified personnel must be trained and experienced in tank design, fabrication, repair, construction, and inspection.

The report has anomalous dates listed. The inspection is dated August 31, 2007; however, the report shows that Steven Hanson (APSC) prepared the report and Robert Annett (APSC) approved the report on October 24, 2005. APSC does not explain how a report with 2007 inspection data could be prepared and approved in 2005.

The 2007 Tank 5 external inspection report also includes data that are inconsistent with the 2001 Tank 5 inspection. In some cases, the 2007 inspection shows less corrosion (thicker roof plates) than what was recorded in 2001.

Recommendation No. 1: PWSRCAC should request additional information from APSC on the 2007 Tank 5 external inspection, including confirmation of the inspector's credentials, a copy of the inspector's original data and report, and confirmation of APSC Engineering Management review and approval.

4. Roof Inspection

There are two standards to consider when evaluating whether to repair or replace a tank roof: (1) the original design criteria and (2) the API 653 standard. The roof plates for Tank 5 were originally designed by APSC at 0.375" thick, including a 0.125" corrosion allowance. Therefore, if the roof thickness is at or above 0.25", it exceeds the original design tolerance. The API 653 standard requires roof plates be repaired or replaced when there are any holes or corrosion reaches an average thickness of less than 0.09" in any 100 in.^{2} area. Typically, the more stringent design standard (i.e. the original tank design criteria) is used instead of a default API standard.

The 2001 internal roof inspection showed corrosion around the pressure relief vent and on plate numbers 8, 18, 23, 110, and 111. Using the roof corrosion rates measured in 2001and APSC's original plate thickness of 0.375", APSC's design corrosion allowance of 0.125", and a critical remaining thickness standard of 0.25", it is estimated that the roof area around the pressure relief vent and near the vapor outlet and on plate numbers 8, 18, 23, 110, and 111 will be thinner than 0.25" in 2014. APSC has requested approval from ADEC to extend the Tank 5 internal inspection from 2012 to 2014.

APSC Engineer Kelly Lee completed a Tank 5 corrosion calculation report on January 29, 2003 that summarized the 2001 inspection data; this report included 12 roof measurements.[2] Lee concluded that the most significant corrosion was found on roof plate 111, and estimated a corrosion rate of 7.2 mpy.

APSC Engineer William Mott completed a Tank 5 corrosion calculation report on September 11, 2011 that summarized the 2001 inspection data; this report included 19 roof measurements.[3] Mott's report included seven more data points than Lee's report, and two data points listed in Lee's report were not included in Mott's report. Lee also concluded that the most significant corrosion was found on roof plate 111, and estimated a corrosion rate of 6.08 mpy.

Mott reports that Anvil Engineering completed a study in 2002 that shows snow and seismic loads can potentially act on VMT tanks, and Anvil Engineering recommended a minimum average roof plate thickness of 0.268" within 25' of the tank shell. Mott does not comment on the 0.25" original design criteria established for Tank 5.

Anvil's findings are supporting HCLLC's longstanding recommendation that a 0.25" threshold should be used for corrosion analysis, rather than API's default standard of 0.09" in any 100 in.^{2} area.

Recommendation No. 2: PWSRCAC should request a copy of the 2002 Anvil Engineering Study and conduct an independent technical review of the study's assumptions and conclusions. PWSRCAC should also request a copy of the Joint Pipeline Agency's and ADEC's review and assessment of this technical work.

Mott concludes that plates 8, 18, 23, 110 and 111 are "isolated pitting and do not have significant effect on plate strength and therefore can be overlooked." Mott made this statement in reference to APSC's request to extend the next internal Tank 5 inspection from 2012 to 2014.

Mott's report did not examine the more current Tank 5 roof data acquired in 2007. It is not clear why the 2007 data were not included in Mott's 2011 assessment.

HCLLC's computations concur with Mott's 6.08 mpy estimated corrosion rate. HCLLC's computations are shown in the attachment labeled Table No. 1 VMT Tank 5 Roof Integrity Based on Year 2001 Internal Inspection Data. Based on the 6.08 mpy corrosion rate, in 2014 the Tank 5 roof area around the pressure relief vent, near the vapor outlet, and on plate numbers 8, 18, 23, 110, and 111 may be thinner than the 0.25" design standard.

There is not sufficient information in the 2003 Lee and 2011 Mott summary reports for HCLLC to conclude that roof corrosion is only isolated pitting. The original inspector's reports and a full inspection dataset are needed to verify if the corrosion is only isolated pitting. These documents are also needed to clarify the inconsistencies between the Lee and Mott reports.

Recommendation No. 3: An extension of the internal inspection to 2014 is not recommended, based on roof corrosion rates extrapolated from the 2001 internal inspection data. A linear computation indicates that roof corrosion in 2014 may exceed the 0.125" corrosion allowance.

[2] 1-29-03 APSC 6 page summary report "X052 TK5 review" Kelly Lee for Tom Stokes.
[3] 9-21-11 APSC 6 page summary report "Revised Corrosion Report 54-TK-5" William Mott for Hally Cooper.

Inspector Lane, who conducted the 2001 Tank 5 inspection, produced a findings report on August 24, 2002. In 2006, as a result of the whistleblower complaints, APSC allowed PWSRCAC and HCLLC to review the August 24, 2002 inspection report prepared by Inspector Lane at its office, but not retain a hard copy.

Inspector Lane's report documented an inability to access the inside of Tank 5's roof; he was only allowed to conduct a visual inspection using a spotlight and binoculars standing on the tank floor. Inspector Lane requested improved access to inspect the inside of the roof and roof support structures. Inspector Lane concluded that the rafters and support beams were in place, but he could not verify their condition; therefore, the rafter and support structure corrosion rates were unknown. Inspector Lane documented that a comprehensive inspection should include access by way of man lift or scaffolding to the underside of the roof, rafters, roof girders, and the top portion of the roof support columns; this allows an inspector to collect metal thickness readings in areas of concern and closely examine welded areas.

HCLLC's March 2007 preliminary investigation report of the alleged Tank 5 integrity concerns concluded that: API 653 requires tank roof inspections to be conducted in a manner, and to the extent acceptable to the inspector; and that the inspector's recommendations were not followed. Inspector Lane recommended an internal and external roof inspection. The internal inspection was not completed per Inspector Lane's recommendations; only external roof corrosion measurements were obtained.

APSC's 2007 external tank inspection was completed by Robert Dale Long, Jr. on August 31, 2007. Long is listed in the report as the "inspector" and a Level II APSC Technician. There is no information in the report to verify whether Long is an API 653 inspector. The inspection included a topside roof visual examination. Additionally, 52 roof thickness measurements were collected by ultrasonic technique. The thinnest roof plate measurement recorded was 0.283".

HCLLC's computations based on the 2007 inspection data are shown in the attachment labeled Table No. 2 VMT Tank 5 Roof Integrity Based on Year 2007 External Inspection Data.

The 2007 external inspection data could not be correlated to the 2001 internal inspection data because the locations of the 2007 UT measurements were not listed by roof plate. Overall, most of the 2007 UT readings are thicker than those taken in 2001; the difference is not noted by the inspector or explained in the APSC report.

Based on the data reported for the 2007 inspection, the roof plates would all exceed a 0.25" critical remaining thickness by 2014. More information is needed from APSC to verify if the data were obtained and quality controlled by an API 653 inspector. Also, the 2001 and 2007 datasets should be correlated, and the differences between them should be explained.

Recommendation No. 4: The roof thickness data that shows less corrosion in 2007 than previously recorded in 2001 should be further examined by obtaining the original, complete inspection records for 2001 and 2007. Anomalous inspection data should be reconciled by the inspector at the time of the inspection, to provide an opportunity for additional data to be collected, if needed at the time of the inspection.

Tank 5 has vapor control installed. Roof integrity is important for the proper function and safety of this system. Tank 5's roof was designed to hold the Valdez, Alaska snow load. The API 653 standard of an average thickness of less than 0.09" in any 100 in.^{2} area does not take into account the snow loading design requirement.

Recommendation No. 5: Roof corrosion should be carefully examined at the next internal inspection in 2012, especially in the areas around the vapor recovery nozzles and pressure relief vents, where corrosion was found. Engineers should ensure thinning does not impact the roof's ability to hold Valdez's snow load, or affect vapor recovery system function.

5. Shell Inspection

The original design criteria for Tank 5 include tank shell thicknesses that vary with height. The tank was constructed with eight tank shell courses: the 1st course at the bottom and the 8th course at the top. The original thickness of the 1st course was 1.121", the 2nd course was 0.969", the 3rd course was 0.832", the 4th course was 0.699", the 5th course was 0.569", and the 6th-8th courses were 0.5". All courses included a 0.125" corrosion allowance.

The 2001 internal inspection obtained ultrasonic measurements at four quadrants around the 1st course of the tank shell. Ultrasonic measurements of the 2nd-8th courses were taken from the tank's staircase. Thickness measurements either exceeded the original design nominal thickness or showed little corrosion. Lee's 2003 and Mott's 2011 engineering assessments both concluded that corrosion to the shell was minor. Mott's report did not examine the more current Tank 5 shell data acquired in 2007; it is not clear why the 2007 data were not included in Mott's 2011 assessment.

HCLLC's computations using the 2001 inspection data are shown in the attachment labeled Table No. 3 VMT Tank 5 Shell Integrity Based on Year 2001 Internal Inspection Data.

As noted in HCLLC's March 2007 preliminary investigation report of the alleged Tank 5 integrity concerns, the inspector that completed the 2001 internal inspection documented concerns that the tank shell was not cleaned of oil above the 1st shell course. Furthermore, the inspector was not provided access to shell courses 2-8. The inspector noted his concern that the UT data collected on the shell at points limited to walking the tank staircase were insufficient to achieve a rigorous statistical analysis of the shell condition.

Additionally, in 2006 and 2007, based on the data provided, HCLLC could not rule out the allegations that no weld preheat was used on the door cut in the tank wall to repair the tank floor. Nor could HCLLC rule out the allegations the joint design on door was improperly approved. HCLLC recommended that PWSRCAC obtain additional records from APSC and consult with a welding expert.

Recommendation No. 6: Agency review of APSC's request to extend Tank 5's next internal inspection beyond 2012 should include a thorough technical analysis of the concerns raised by Inspector Lane in 2001.

The 2007 external inspection obtained 36 ultrasonic measurements on the 1st tank course and one ultrasonic measurement on each of the 2nd through 8th tank courses. Thickness measurements either exceeded the original design nominal thickness or showed little corrosion.

HCLLC's computations using the 2007 inspection data are shown in the attachment labeled Table No. 4 VMT Tank 5 Shell Integrity Based on Year 2007 External Inspection Data.

Assuming the corrosion rate is linear, and does not accelerate, shell plate thicknesses should remain well above the design thresholds by the next proposed inspection in 2014.

6. Annular Ring Plate Inspection

Tank 5's design includes a 13/16" annular ring (0.8125" thick) made of 34 butt-welded plates.

In 2001, Manual Ultrasonic Testing (MUT) was used to examine 100% of the exposed surface of the annular plate ring. The 2001 MUT testing showed corrosion on the annular plates, with the most significant corrosion on plates A4 and A17.

APSC Engineer Kelly Lee completed a corrosion calculation report on January 29, 2003 that summarized the 2001 inspection data; this report included data on all 34 annular ring plates.[4] Lee concluded that the most significant corrosion was found on roof plate A17, and estimated a corrosion rate of 5.1 mpy. Lee's report does not assess whether this corrosion rate is acceptable.

APSC Engineer William Mott completed a corrosion calculation report on September 11, 2011 that summarized the 2001 annular ring plate inspection data.[5] Of note, the data used in Mott's analysis was different than the data used in Lee's analysis for plates A4, A5, and A7. Mott's analysis showed that the MUT thicknesses were less than what was reported by Lee. Yet, both individuals were reportedly using the same 2001 dataset. For this reason, HCLLC has consistently recommended that PWSRCAC obtain the original tank inspection report, rather than rely on summaries prepared by APSC.

Mott reports that in 2008 APSC completed a Finite Element Analysis (FEA) to determine the minimum allowable continuous and isolated annular plate thicknesses. Mott reports that the FEA took into account seismic and structural factors, and concluded that the minimum allowable continuous annular plate thickness is 0.58". Mott also reports that the FEA concluded that an isolated pit on the annular ring does not affect the structural or seismic integrity of the tank, and the minimum allowable thickness for an isolated pit is 0.10".

HCLLC's VMT tank analysis reports have consistently identified the lack of engineering assessments on minimum allowable annular plate thicknesses as an issue. The completion of the FEA was a positive step in tank inspection analysis for the VMT. HCLLC has been using 0.58" as the annular plate corrosion threshold. HCLLC based this threshold on the original tank design data from 1976. Therefore, the FEA's 0.58" minimum allowable continuous annular plate thickness is consistent with HCLLC's previous methodology.

However, HCLLC has requested, but not received, APSC's analysis on the minimum allowable thickness for isolated pits. It would be helpful to obtain this data for further review for this tank assessment and future tank assessments.

Recommendation No. 7: PWSRCAC should request a copy of the 2008 APSC Finite Element Analysis and conduct an independent technical review of the study's assumptions and conclusions. PWSRCAC should also request a copy of the Joint Pipeline Agency's review and assessment of this technical work.

Mott's analysis concluded that the most significant corrosion on the annular ring occurred on plate A4, and estimated a corrosion rate of 6.38 mpy.

HCLLC's computations concur with Mott's conclusion that the most significant corrosion has occurred on plate A4 and the estimated corrosion rate is 6.38 mpy. HCLLC's computations are shown in the

[4] 1-29-03 APSC 6 page summary report "X052 TK5 review" Kelly Lee for Tom Stokes.
[5] 9-21-11 APSC 6 page summary report "Revised Corrosion Report 54-TK-5" William Mott for Hally Cooper.

attachment labeled Table No. 5 VMT Tank 5 Annular Ring Integrity Based on Year 2001 Internal Inspection Data.

Mott concludes that the corrosion on plate A4 is isolated pitting. Mott has access to the full 2001 inspection report and dataset, providing him the data needed to draw that conclusion. APSC has not provided the original, complete 2001 inspection report and dataset to PWSRCAC, so it is not possible to verify Mott's "isolated pitting" conclusion. This point should be verified with APSC by obtaining the original annular plate corrosion dataset.

HCLLC's computations show that corrosion on plate A14 may reduce plate thickness to 0.57" by 2014 (based on 2001 measurements). A 0.57" thickness would be of concern if corrosion covered a significant portion of the plate, instead of isolated pitting. Therefore, Mott's conclusion that plate A14's corrosion is only isolated pitting should be confirmed by a review of the original inspection records.

Recommendation No. 7: PWSRCAC should request a complete copy of the 2001 Tank 5 API Inspector's Report and accompanying dataset to verify APSC's conclusion that corrosion of the annular ring is "isolated pitting."

7. Floor Inspection

In 2002, Tank 5's tank floor was replaced due to soil side corrosion. A new tank floor was built from 265 steel plates (0.25" thick) that were welded together. A foot of clean sand was placed under the new tank floor and an impressed current cathodic protection system was installed, using APSC's project X052 specifications, to protect the tank floor from the corrosive effects of the soil. The new tank floor was coated. The shell and columns were also coated three feet up from the floor.

API 653 requires the operator to re-enter the tank 10 years after the installation of a new tank floor to obtain a corrosion rate, or use similar service data from a nearby tank. This API 653 requirement is in place because it is not possible to estimate a corrosion rate for a tank floor bottom that has not been inspected since it was installed.

ADEC does not allow the substitution of data from a nearby tank in similar service to be used to estimate the corrosion rate (18 AAC 75.065(b)(2)). Therefore, ADEC requires an internal inspection be completed to establish a new 10-year floor corrosion rate. However, an operator may obtain a waiver of the inspection requirement by submitting a quantitative risk assessment under 18 AAC 75.065(b)(3). The risk assessment must be signed by a registered engineer and conducted in accordance with American Petroleum Institute Recommended Practice No. 580 (API 580), Risk Based Inspection, First Edition, May 2002. Alternatively, a waiver of the inspection requirement may be requested by an operator if it can show an equivalent level of oil spill protection will be achieved by using a technology or procedure (18 AAC 75.025(a)).

In the case of Tank 5, the tank floor corrosion rate is not known, because a new floor was installed in 2002. ADEC regulations require an internal inspection within 10 years to establish a corrosion rate for new tank floors. Tank 5's internal inspection is due in 2012. APSC has not submitted a risk-based inspection assessment that would support the extension of the inspection to 2014.

Recommendation No. 8: An internal tank inspection is needed in 2012 to establish a 10-year corrosion rate on the Tank 5 floor installed in 2001.

Additionally, HCLLC's March 2007 preliminary investigation report of the alleged Tank 5 integrity concerns concluded that several allegations raised by concerned employees regarding the new tank floor could not be fully evaluated due to a lack of data. These allegations included:

1. The material used to replace the floor was substandard;
2. The floor bottom plates were improperly tested; and
3. The floor plates were improperly welded to the annular ring.

An API 653 internal inspection requires the tank be emptied and cleaned. Sediment and sludge has historically been found in Tank 5, and other VMT Crude Oil Tanks during internal inspections. The fire protection system for Tank 5 includes a foam distribution system located above the tank floor at the bottom of the tank. Sediment buildup over this system can cause blockages, potentially impacting foam distribution and concentration. Routine internal inspections are an important fire prevention measure.

Recommendation No. 9: Due to the size and age of Tank 5, and its location in a critically sensitive habitat and Zone 4 earthquake area, a minimum inspection regime of 10 year internal inspections and 5 year external inspections is recommended, with more frequent inspections if warranted.

Table No. 1

VMT Tank 5 Roof Integrity Based on Year 2001 Internal Inspection Data

Design Information from APSC

0.375"	Original Plate Thickness
0.125"	Original Design Corrosion Allowance
0.250"	Critical Remaining Thickness = 0.375"-0.125" (APSC Original Design Standard, includes seismic and snow loading)
1976	Tank Installation Date
2001	Internal Inspection
2012	Next Inspection Due
2014	Next Inspection Proposed by APSC

By Year 2014, the roof plates highlighted in yellow below are estimated to have corrosion loss exceeding APSC's design standard.

Data Source: 1-29-03 APSC 6 page summary report "X052 TK5 review" Kelly Lee to Tom Stokes and 9-21-11 APSC 6 page summary report "Revised Corrosion Report 54-TK-5" William Mott to Hally Cooper. Reports contain some different data. There were 19 data points in Mott's report, and only 12 data points in Lee's report (2 data points listed in Lee's report were not listed in Mott's).

Plate Number	Original Nominal Thickness (inches)	Measured Thickness in 2001 Internal Inspection	Roof Plate Loss in 2001 (inches)	API 653 Compliant in 2001? (Note 1)	Remaining Corrosion Allowance (inches)	Corrosion Rate for Period 1976 to 2001 (mpy)	Calculated Plate Thickness in 2014; Based on 2001 Corrosion Rate (inches)	Estimated Roof Plate Loss by 2014 (inches)	Estimated to be API 653 Compliant in 2014? (Note 1)	Estimated % Roof Plate Loss by 2014 (Note 1)
8	0.375	0.241	0.134	No	(0.009)	5.36	0.171	0.204	No	54%
18	0.375	0.234	0.141	No	(0.016)	5.64	0.161	0.214	No	57%
23	0.375	0.241	0.134	No	(0.009)	5.36	0.171	0.204	No	54%
89	0.375	0.353	0.022	Yes	0.103	0.88	0.342	0.033	Yes	9%
94	0.375	0.341	0.034	Yes	0.091	1.36	0.323	0.052	Yes	14%
95	0.375	0.338	0.037	Yes	0.088	1.48	0.319	0.056	Yes	15%
96	0.375	0.352	0.023	Yes	0.102	0.92	0.340	0.035	Yes	9%
106	0.375	0.373	0.002	Yes	0.123	0.08	0.372	0.003	Yes	1%
107	0.375	0.322	0.053	Yes	0.072	2.12	0.294	0.081	Yes	21%
108	0.375	0.285	0.090	Yes	0.035	3.60	0.238	0.137	No	36%
109	0.375	0.263	0.112	Yes	0.013	4.48	0.205	0.170	No	45%
110	0.375	0.244	0.131	No	(0.006)	5.24	0.176	0.199	No	53%
111	0.375	0.223	0.152	No	(0.027)	6.08	0.144	0.231	No	62%
112	0.375	0.260	0.115	Yes	0.010	4.60	0.200	0.175	No	47%
113	0.375	0.296	0.079	Yes	0.046	3.16	0.255	0.120	Yes	32%
122	0.375	0.331	0.044	Yes	0.081	1.76	0.308	0.067	Yes	18%
127	0.375	0.361	0.014	Yes	0.111	0.56	0.354	0.021	Yes	6%
128	0.375	0.337	0.038	Yes	0.087	1.52	0.317	0.058	Yes	15%
137	0.375	0.344	0.031	Yes	0.094	1.24	0.328	0.047	Yes	13%
138	0.375	0.363	0.012	Yes	0.113	0.48	0.357	0.018	Yes	5%
199	0.375	0.304	0.071	Yes	0.054	2.84	0.267	0.108	Yes	29%
radius around pressure relief vent	0.375	0.034	0.341	No	(0.216)	13.64	(0.143)	0.518	No	138%
radius around vapor inlet	0.375	0.319	0.056	Yes	0.069	2.24	0.290	0.085	Yes	23%
radius around vapor outlet	0.375	0.285	0.090	Yes	0.035	3.60	0.238	0.137	No	36%

Note 1: In the event that live roof loads exceed 25 lb/sq.ft. (e.g. high snow loading) then the roof plate thickness must be based on API 650; therefore the analysis used the original minimum design thickness tank design of 0.25", rather than the minimum thickness of 0.09 (per API 653 Section 9.11.1.1).

No information was provided on roof support member inspections.

Table No. 2

VMT Tank 5 Roof Integrity Based on Year 2007 External Inspection Data

Design Information from APSC

0.375"	Original Plate Thickness
0.125"	Original Design Corrosion Allowance
0.250"	Critical Remaining Thickness = 0.375"-0.125" (APSC Original Design Standard, includes seismic and snow loading)
1976	Tank Installation Date
2007	External Inspection
2012	Next Inspection Due
2014	Next Inspection Proposed by APSC

By Year 2014, all roof plates are estimated to be within APSC's design corrosion allowance.

Data Source: 8-31-07 APSC 5-Year API 653 External Inspection Report Tank 5; Ultrasonic Testing (UT)

Reading Location	Original Nominal Thickness (inches)	Measured Thickness in 2007 External Inspection (inches)	Roof Plate Loss in 2007 (inches)	API 653 Compliant in 2007? (Note 1)	Remaining Corrosion Allowance (inches)	Corrosion Rate for Period 1976 to 2007 (mpy)	Calculated Plate Thickness in 2014; Based on 2007 Corrosion Rate (inches)	Estimated Roof Plate Loss by 2014 (inches)	Estimated to be API 653 Compliant in 2014? (Note 1)	Estimated % Roof Plate Loss by 2014 (Note 1)
North 1	0.375	0.330	0.045	Yes	0.080	1.45	0.320	0.055	Yes	15%
North 2	0.375	0.304	0.071	Yes	0.054	2.29	0.288	0.087	Yes	23%
North 3	0.375	0.313	0.062	Yes	0.063	2.00	0.299	0.076	Yes	20%
North 4	0.375	0.337	0.038	Yes	0.087	1.23	0.328	0.047	Yes	12%
North 5	0.375	0.302	0.073	Yes	0.052	2.35	0.286	0.089	Yes	24%
North 6	0.375	0.284	0.091	Yes	0.034	2.94	0.263	0.112	Yes	30%
North 7	0.375	0.301	0.074	Yes	0.051	2.39	0.284	0.091	Yes	24%
North 8	0.375	0.281	0.094	Yes	0.031	3.03	0.260	0.115	Yes	31%
North 9	0.375	0.360	0.015	Yes	0.110	0.48	0.357	0.018	Yes	5%
North 10	0.375	0.355	0.020	Yes	0.105	0.65	0.350	0.025	Yes	7%
North 11	0.375	0.362	0.013	Yes	0.112	0.42	0.359	0.016	Yes	4%
North 12	0.375	0.353	0.022	Yes	0.103	0.71	0.348	0.027	Yes	7%
North 13	0.375	0.354	0.021	Yes	0.104	0.68	0.349	0.026	Yes	7%
South 1	0.375	0.355	0.020	Yes	0.105	0.65	0.350	0.025	Yes	7%
South 2	0.375	0.337	0.038	Yes	0.087	1.23	0.328	0.047	Yes	12%
South 3	0.375	0.352	0.023	Yes	0.102	0.74	0.347	0.028	Yes	8%
South 4	0.375	0.348	0.027	Yes	0.098	0.87	0.342	0.033	Yes	9%
South 5	0.375	0.338	0.037	Yes	0.088	1.19	0.330	0.045	Yes	12%
South 6	0.375	0.346	0.029	Yes	0.096	0.94	0.339	0.036	Yes	9%
South 7	0.375	0.354	0.021	Yes	0.104	0.68	0.349	0.026	Yes	7%
South 8	0.375	0.343	0.032	Yes	0.093	1.03	0.336	0.039	Yes	10%
South 9	0.375	0.283	0.092	Yes	0.033	2.97	0.262	0.113	Yes	30%
South 10	0.375	0.345	0.030	Yes	0.095	0.97	0.338	0.037	Yes	10%
South 11	0.375	0.318	0.057	Yes	0.068	1.84	0.305	0.070	Yes	19%
South 12	0.375	0.328	0.047	Yes	0.078	1.52	0.317	0.058	Yes	15%
South 13	0.375	0.344	0.031	Yes	0.094	1.00	0.337	0.038	Yes	10%
East 1	0.375	0.355	0.020	Yes	0.105	0.65	0.350	0.025	Yes	7%
East 2	0.375	0.360	0.015	Yes	0.110	0.48	0.357	0.018	Yes	5%
East 3	0.375	0.328	0.047	Yes	0.078	1.52	0.317	0.058	Yes	15%
East 4	0.375	0.300	0.075	Yes	0.050	2.42	0.283	0.092	Yes	25%
East 5	0.375	0.314	0.061	Yes	0.064	1.97	0.300	0.075	Yes	20%
East 6	0.375	0.340	0.035	Yes	0.090	1.13	0.332	0.043	Yes	11%
East 7	0.375	0.324	0.051	Yes	0.074	1.65	0.312	0.063	Yes	17%
East 8	0.375	0.340	0.035	Yes	0.090	1.13	0.332	0.043	Yes	11%
East 9	0.375	0.318	0.057	Yes	0.068	1.84	0.305	0.070	Yes	19%
East 10	0.375	0.355	0.020	Yes	0.105	0.65	0.350	0.025	Yes	7%
East 11	0.375	0.340	0.035	Yes	0.090	1.13	0.332	0.043	Yes	11%
East 12	0.375	0.371	0.004	Yes	0.121	0.13	0.370	0.005	Yes	1%
East 13	0.375	0.322	0.053	Yes	0.072	1.71	0.310	0.065	Yes	17%
West 1	0.375	0.345	0.030	Yes	0.095	0.97	0.338	0.037	Yes	10%
West 2	0.375	0.325	0.050	Yes	0.075	1.61	0.314	0.061	Yes	16%
West 3	0.375	0.303	0.072	Yes	0.053	2.32	0.287	0.088	Yes	24%
West 4	0.375	0.322	0.053	Yes	0.072	1.71	0.310	0.065	Yes	17%
West 5	0.375	0.341	0.034	Yes	0.091	1.10	0.333	0.042	Yes	11%
West 6	0.375	0.316	0.059	Yes	0.066	1.90	0.303	0.072	Yes	19%
West 7	0.375	0.300	0.075	Yes	0.050	2.42	0.283	0.092	Yes	25%
West 8	0.375	0.332	0.043	Yes	0.082	1.39	0.322	0.053	Yes	14%
West 9	0.375	0.325	0.050	Yes	0.075	1.61	0.314	0.061	Yes	16%
West 10	0.375	0.317	0.058	Yes	0.067	1.87	0.304	0.071	Yes	19%
West 11	0.375	0.316	0.059	Yes	0.066	1.90	0.303	0.072	Yes	19%
West 12	0.375	0.347	0.028	Yes	0.097	0.90	0.341	0.034	Yes	9%
West 13	0.375	0.323	0.052	Yes	0.073	1.68	0.311	0.064	Yes	17%

Note 1: In the event that live roof loads exceed 25 lb/sq.ft. (e.g. high snow loading) then the roof plate thickness must be based on API 650; therefore the analysis used the original minimum design thickness of 0.25" for the tank, rather than the minimum thickness of 0.09 (per API 653 Section 9.11.1.1)

No information was provided on roof support member inspections.

Table No. 3

VMT Tank 5 Shell Integrity Based on Year 2001 Internal Inspection Data

Design Information from APSC

Varies by Course	Original Plate Thickness
0.125"	Original Design Corrosion Allowance
1976	Tank Installation Date
2001	Internal Inspection
2012	Next Inspection Due
2014	Next Inspection Proposed by APSC

By Year 2014, all shell plates are estimated to be within APSC's design corrosion allowance.

Data Source: 1-29-03 APSC 6 page summary report "X052 TK5 review" Kelly Lee to Tom Stokes and 9-21-11 APSC 6 page summary report "Revised Corrosion Report 54-TK-5" William Mott to Hally Cooper.

Course	Original Nominal Thickness (inches)	Measured Thickness in 2001 Internal Inspection (Note 3)	Plate Loss in 2001 (inches)	API 653 Compliant in 2001?	Remaining Corrosion Allowance (inches)	Corrosion Rate (mpy)	Calculated Thickness in 2014; Based on 2001 Corrosion Rate (inches)	Estimated Corrosion Loss by 2014 (inches)	Corrosion Loss of Less Than 0.125" by 2014 (Note 1)	Estimated % Shell Loss by 2014 (Note 2)
8	0.500	0.477	0.023	Yes	0.102	0.92	0.454	0.046	Yes	9%
8	0.500	0.479	0.021	Yes	0.104	0.84	0.458	0.042	Yes	8%
8	0.500	0.493	0.007	Yes	0.118	0.28	0.486	0.014	Yes	3%
7	0.500	0.483	0.017	Yes	0.108	0.68	0.466	0.034	Yes	7%
7	0.500	0.497	0.003	Yes	0.122	0.12	0.494	0.006	Yes	1%
7	0.500	0.512	0.000	Yes	0.125	0.00	0.512	0.000	Yes	0%
6	0.500	0.517	0.000	Yes	0.125	0.00	0.517	0.000	Yes	0%
6	0.500	0.524	0.000	Yes	0.125	0.00	0.524	0.000	Yes	0%
6	0.500	0.520	0.000	Yes	0.125	0.00	0.520	0.000	Yes	0%
5	0.569	0.566	0.003	Yes	0.122	0.12	0.563	0.006	Yes	1%
5	0.569	0.573	0.000	Yes	0.125	0.00	0.573	0.000	Yes	0%
5	0.569	0.535	0.034	Yes	0.091	1.36	0.501	0.068	Yes	12%
			0.000							
4	0.699	0.707	0.000	Yes	0.125	0.00	0.707	0.000	Yes	0%
4	0.699	0.691	0.008	Yes	0.117	0.32	0.683	0.016	Yes	2%
4	0.699	0.699	0.000	Yes	0.125	0.00	0.699	0.000	Yes	0%
3	0.832	0.831	0.001	Yes	0.124	0.04	0.830	0.002	Yes	0%
3	0.832	0.843	0.000	Yes	0.125	0.00	0.843	0.000	Yes	0%
3	0.832	0.836	0.000	Yes	0.125	0.00	0.836	0.000	Yes	0%
2	0.969	0.996	0.000	Yes	0.125	0.00	0.996	0.000	Yes	0%
2	0.969	0.980	0.000	Yes	0.125	0.00	0.980	0.000	Yes	0%
2	0.969	0.993	0.000	Yes	0.125	0.00	0.993	0.000	Yes	0%
1	1.121	1.123	0.000	Yes	0.125	0.00	1.123	0.000	Yes	0%
1	1.121	1.118	0.003	Yes	0.122	0.12	1.115	0.006	Yes	1%
1	1.121	1.137	0.000	Yes	0.125	0.00	1.137	0.000	Yes	0%
1	1.121	1.120	0.001	Yes	0.124	0.04	1.119	0.002	Yes	0%

Note 1: Used APSC's design criteria of 0.125" corrosion loss tolerance in corrosion loss calculation.

Note 2: This calculation was completed without any additional data points to determine any change in the corrosion rate since 2001

Note 3: Only 3 readings were taken per shell course from the exterior. There are 18 plates per shell therefore only 17% of the plates were examined. Data was taken from outside the tank with no correction for coating thickness.

Table No. 4

VMT Tank 5 Shell Integrity Based on Year 2007 External Inspection Data

Design Information from APSC

Varies by Course	Original Plate Thickness
0.125"	Original Design Corrosion Allowance
1976	Tank Installation Date
2001	Internal Inspection
2007	External Inspection
2012	Next Inspection Due
2014	Next Inspection Proposed by APSC

By Year 2014, all shell plates are estimated to be within APSC's design corrosion allowance.

Data Source: 8-31-07 APSC 5-Year API 653 External Inspection Report Tank 5; Ultrasonic Testing (UT)

Course	Measured Thickness in 2001 Internal Inspection	Measured Thickness in 2007 External Inspection	Plate Loss from year 2001 to 2007 (inches)	Original Nominal Thickness (inches)	Plate Loss from year 1976 to 2005 (inches)	API 653 Compliant in 2001?	Remaining Corrosion Allowance (inches)	Corrosion Rate (mpy)	Calculated Thickness in 2014; Based on 2007 Corrosion Rate (inches)	Estimated Corrosion Loss by 2014 (inches)	Corrosion Loss of Less Than 0.125" by 2014 (Note 1)	Estimated % Shell Loss by 2014
8	0.477	0.480	0.000	0.500	0.020	Yes	0.105	0.00	0.480	0.020	Yes	4%
8	0.479	0.480	0.000	0.500	0.020	Yes	0.105	0.00	0.480	0.020	Yes	4%
8	0.493	0.480	0.013	0.500	0.020	Yes	0.105	2.17	0.465	0.035	Yes	7%
7	0.483	0.489	0.000	0.500	0.011	Yes	0.114	0.00	0.489	0.011	Yes	2%
7	0.497	0.489	0.008	0.500	0.011	Yes	0.114	1.33	0.480	0.020	Yes	4%
7	0.512	0.489	0.023	0.500	0.011	Yes	0.114	3.83	0.462	0.038	Yes	8%
6	0.517	0.515	0.002	0.500	0.000	Yes	0.125	0.33	0.513	0.000	Yes	0%
6	0.524	0.515	0.009	0.500	0.000	Yes	0.125	1.50	0.505	0.000	Yes	0%
6	0.520	0.515	0.005	0.500	0.000	Yes	0.125	0.83	0.509	0.000	Yes	0%
5	0.566	0.566	0.000	0.569	0.003	Yes	0.122	0.00	0.566	0.003	Yes	1%
5	0.573	0.566	0.007	0.569	0.003	Yes	0.122	1.17	0.558	0.011	Yes	2%
5	0.535	0.566	0.000	0.569	0.003	Yes	0.122	0.00	0.566	0.003	Yes	1%
			0.000									
4	0.707	0.702	0.005	0.699	0.000	Yes	0.125	0.83	0.696	0.003	Yes	0%
4	0.691	0.702	0.000	0.699	0.000	Yes	0.125	0.00	0.702	0.000	Yes	0%
4	0.699	0.702	0.000	0.699	0.000	Yes	0.125	0.00	0.702	0.000	Yes	0%
3	0.831	0.840	0.000	0.832	0.000	Yes	0.125	0.00	0.840	0.000	Yes	0%
3	0.843	0.840	0.003	0.832	0.000	Yes	0.125	0.50	0.837	0.000	Yes	0%
3	0.836	0.840	0.000	0.832	0.000	Yes	0.125	0.00	0.840	0.000	Yes	0%
2	0.996	0.980	0.016	0.969	0.000	Yes	0.125	2.67	0.961	0.008	Yes	1%
2	0.980	0.980	0.000	0.969	0.000	Yes	0.125	0.00	0.980	0.000	Yes	0%
2	0.993	0.980	0.013	0.969	0.000	Yes	0.125	2.17	0.965	0.004	Yes	0%
1	1.123	1.120	0.003	1.121	0.001	Yes	0.124	0.50	1.117	0.004	Yes	0%
1	1.118	1.110	0.008	1.121	0.011	Yes	0.114	1.33	1.101	0.020	Yes	2%
1	1.137	1.120	0.017	1.121	0.001	Yes	0.124	2.83	1.100	0.021	Yes	2%
1	1.120	1.120	0.000	1.121	0.001	Yes	0.124	0.00	1.120	0.001	Yes	0%

Note 1: Used APSC's design criteria of 0.125" corrosion loss tolerance in corrosion loss calculation.

Table No. 5

VMT Tank 5 Annular Ring Integrity Based on Year 2001 Internal Inspection Data

Design Information from APSC

1976	Tank Installation Date
2001	Internal Inspection
2012	Next Inspection Due
2014	Next Inspection Proposed by APSC

Data Source: 1-29-03 APSC 6 page summary report "X052 TK5 review" Kelly Lee to Tom Stokes and 9-21-11 APSC 6 page summary report "Revised Corrosion Report 54-TK-5" William Mott to Hally Cooper. Lee's data included 34 MUT measurements (plates A1 through A34). Mott's data only included MUT measurements on plates A1- A17. Mott's data showed thinner plates at A4, A5, and A6. Mott's data for plates at A4, A5, and A6 was used to be conservative.

Plate Number	Original Nominal Thickness (inches)	Measured Thickness in 2001 Internal Inspection (inches)	Ring Loss in 2001 (inches)	Corrosion Rate (mpy)	Calculated Thickness in 2014; Based on 2001 Corrosion Rate (inches)	Estimated Corrosion Loss by 2014 (inches)	Estimated % Ring Loss by 2014
1	0.8125	0.761	0.052	2.06	0.734	0.078	10%
2	0.8125	0.759	0.054	2.14	0.731	0.081	10%
3	0.8125	0.734	0.079	3.14	0.693	0.119	15%
4	0.8125	0.653	0.160	6.38	0.570	0.242	30%
5	0.8125	0.745	0.068	2.70	0.710	0.103	13%
6	0.8125	0.717	0.096	3.82	0.667	0.145	18%
7	0.8125	0.696	0.117	4.66	0.635	0.177	22%
8	0.8125	0.736	0.077	3.06	0.696	0.116	14%
9	0.8125	0.749	0.064	2.54	0.716	0.097	12%
10	0.8125	0.789	0.024	0.94	0.777	0.036	4%
11	0.8125	0.725	0.088	3.50	0.680	0.133	16%
12	0.8125	0.776	0.037	1.46	0.757	0.055	7%
13	0.8125	0.746	0.067	2.66	0.711	0.101	12%
14	0.8125	0.750	0.063	2.50	0.718	0.095	12%
15	0.8125	0.769	0.044	1.74	0.746	0.066	8%
16	0.8125	0.778	0.035	1.38	0.760	0.052	6%
17	0.8125	0.684	0.129	5.14	0.617	0.195	24%
18	0.8125	0.733	0.080	3.18	0.692	0.121	15%
19	0.8125	0.757	0.056	2.22	0.728	0.084	10%
20	0.8125	0.765	0.048	1.90	0.740	0.072	9%
21	0.8125	0.714	0.099	3.94	0.663	0.150	18%
22	0.8125	0.732	0.081	3.22	0.690	0.122	15%
23	0.8125	0.740	0.073	2.90	0.702	0.110	14%
24	0.8125	0.764	0.049	1.94	0.739	0.074	9%
25	0.8125	0.760	0.053	2.10	0.733	0.080	10%
26	0.8125	0.715	0.098	3.90	0.664	0.148	18%
27	0.8125	0.753	0.060	2.38	0.722	0.090	11%
28	0.8125	0.768	0.045	1.78	0.745	0.068	8%
29	0.8125	0.775	0.038	1.50	0.756	0.057	7%
30	0.8125	0.760	0.053	2.10	0.733	0.080	10%
31	0.8125	0.732	0.081	3.22	0.690	0.122	15%
32	0.8125	0.753	0.060	2.38	0.722	0.090	11%
33	0.8125	0.757	0.056	2.22	0.728	0.084	10%
34	0.8125	0.770	0.043	1.70	0.748	0.065	8%

Note 1: Per API 653, Section 4.4.8.4 Tanks that use thickened annular plates for seismic considerations, a seismic evaluation shall be performed using the actual thickness of the existing annular plate.