TN Department of Environment & Conservation

Low Level Testing Guidance for Volumetric Tank Tightness Testing Methods

Published by NWGLDE September 21, 2015

Standard Test Procedures for Evaluating Leak Detection Methods: Volumetric Tank Tightness Testing Methods, EPA, March, 1990 (hereinafter the "VTTT Protocol") states on page 32:

"Product Level
If all tests are done at the same product level, report that level on the results form. If testing was done at different levels, report the applicable product level as the acceptable range (e.g. from 60% to 90% full) used in the testing."

The VTTT Protocol did not establish specific guidance for tank testing at low product levels. A VTTT evaluation consists of 24 valid tests done according to the experimental design described in Section 6. **Testing Procedure.**
If a vendor wishes for a method to be listed on the NWGLDE List for testing at low product levels, the following Steps must be followed during the evaluation and submitted with the evaluation.

1. The equipment must have at least 24 tests done at the 90-95% full level, at least 8 tests done at the 50% full level and at least 8 tests done at the lowest product level for which the vendor wishes the method to be certified and according to the limitations of the equipment as follows:

Nominal Leak Rate	Number of tests at 90-95%	Number of tests at 50%	If lower level is desired (test at X level)
0.0 gph	6	2	2
0.05 gph	6	2	4
0.1 gph	6	2	1
0.2 gph	6	2	1
Total Number of Tests	24	8	8

2. The evaluator must compare the results of the testing done for the two groups at the different levels and complete the additional calculations described in Section 7.3.5 (Test for Effect of In-Tank Product Volume) of **Standard Test Procedures for Evaluating Leak Detection Methods: Automatic Tank Gauging Systems**. The results of this comparison must indicate that the equipment performed equally well at both levels. The results of all seven steps of this calculation must be submitted to the NWGLDE.

3. The evaluator must describe any technical or physical limitations of the equipment for testing at low levels.

4. The evaluator must describe how the method determines the level of groundwater outside the tank and compensates for the effects of groundwater during the test.

5. The evaluator must describe any differences in testing at low levels vs. testing at 90-95% full (i.e. test times, etc.) if there are any.

6. A Results certification that includes the approved product level range must be signed and submitted by the evaluator.

NOTE: Implementing agencies may not accept test results of a tightness test from a tank less than 90-95% full. Implementing agencies may require an ullage test to be performed in conjunction with an underfill test to ensure that the entire tank is tested.

With permission of Dr. Jerry Flora, the following memo is included as supporting information:

Memo:
From: Jairus D. Flora, Jr., Ph.D.

Subject: Recommendations for TTT Evaluation Testing

Date: April 28, 2015

I recommend maintaining the test matrix with 24 tests with the liquid level at the 90-95% level using the 4 nominal leak rates of 0, 0.05, 0.1, and 0.2 gph.

If testing at a lower level is desired, supplement the high level tests by adding 8 tests at the mid point using 2 tests at each of the 4 nominal leak rates (of 0, 0.05, 0.1, and 0.2 gph). Also supplement by adding an ullage test evaluated to show that it can detect a leak rate [equivalent] of 0.1 gph liquid with the ullage of 25 to 75% of the tank volume (using 3 volume levels). The ullage test must be used in conjunction with the TTT whenever the tank to be tested is less than, say 85% full.

It testing at a lower level in the tank is desired, supplement the testing by adding 8 more tests at the lowest liquid level desired using the 4 nominal leak rates. The ullage test must be used in conjunction with the TTT whenever the tank to be tested is less than, say 85% full.

The reasons behind these recommendations are discussed below.

Test Plan for Annual (0.1 gph) testing

The 1990 EPA protocol for evaluating tank tightness test methods calls for 24 tests all at the 90-95% level of the tank. The tank tightness test (TTT) methods must be able to detect a leak rate of 0.1 gallon per hour (gph) with a probability of detection (PD) of at least 95% and a probability of false alarm (PFA) of no more than 5%. The reason that all of the tests are scheduled at the full tank level is because the regulations state that the TTT methods must be capable of detecting a leak from any portion of the tank that routinely contains [liquid] product. Since the required overfill prevention devices require that the filling the tank be stopped when the product reaches 90-95% of capacity, that level was taken as the portion of the tank that routinely contains product. For quantitative methods, testing was done at 4 leak rates: 0 gph (tight); 0.05 gph; 0.1 gph; and 0.2 gph. There are a number of reasons for using non-zero leak rates other than the standard of 0.1 gph. First, some methods claim to find smaller leaks; second, this provides a check on the method's ability to measure the leak rate; third, it also shows that the method can find leaks that are somewhat larger than the target. Clearly one would not want to miss larger leak rates. Generally, the leak rates are not reproduced exactly, but some random variation is introduced so that a method must accurately measure the leak rate and report it--it cannot simply pick one of the 4 nominal leak rates to report. (Qualitative methods use only 0 and about the standard, but require more tests.)

There are some TTT methods that can test when the liquid product level is below 90%. However, when this is the case, such methods must generally be supplemented by another test method that tests the ullage space (that space above the liquid level) of the tank. In this case, it would be permissible to do a TTT evaluation at a lower liquid level than 90%, provided that the method also includes a supplemental test of the ullage space and that this supplemental test is evaluated to show that it can detect a leak in the ullage space. The leak in the ullage space is usually defined as a hole that would allow for liquid product to leak through it at a rate of 0.1 gph at a stated pressure (usually equivalent to about 2 feet of product head).

Recently it has been proposed to do TTT at lower liquid levels in the tank. Specifically, the 50% level (half full) has been mentioned, as well as a low level, perhaps between 15% and 20% full.

I am not certain what the rationale for wanting to test at these levels is. Perhaps the intent is to use an automatic tank gauge as a TTT, provided that it can detect leak rates of 0.1 gph and ATGs are routinely tested at 90-95% and 50%. They are also used at whatever level the product is in the tank when there is a quiet period, so some vendors may want to define its leak detection capability at a lower level than 50% or some regulators may want to know how well it functions at a liquid level of 15 or 20%.

Here are some considerations about testing.

First, testing at the full level is generally the most difficult. The full level usually happens only after a tank is filled. Filling the tank introduces product that may be at a different temperature than the product in the tank or the ground temperature. This will introduce a temperature effect as the product seeks temperature equilibrium. Since the effect on volume of a temperature change is proportional to the liquid volume, the temperature effect will be largest when the tank is full. Other effects from filling the tank include effects on the tank shell or backfill from the additional loading. Thus, there may be expansion of the tank from the increased pressure.

Second, when the tank is 50% full, the surface area is maximized, so any method that depends on measuring a change in liquid level as volume is removed will have the smallest liquid level change for given volume at the mid point. On the other hand, the thermal effect will be smaller, since there is less volume. In addition, usually it takes enough time for the usage to bring the volume down to 50% to bring about temperature stabilization, so thermal expansion or contraction effects are minimized. In dealing with a real leak, the leak rate would be less than when the tank is full because the pressure at the hole would be less with the liquid level at 50% than at 90%. However, this is not a factor if a leak is simulated or induced and the leak rate is controlled.

Third, testing at a lower level (e.g. 15-20%) would be easier than at the 50% level, assuming the leak rate is induced at the same rate as with the higher tests. The reason for this is that temperature effects would be even further reduced. In addition, the surface area at a low level in the tank is reduced compared to the maximum at 50%, so level changes for a given volume would be larger and easier to measure. Thus, testing at the low level represents the easiest case for testing.

If a tank had a real leak, on the other hand, it would be difficult to detect at the low level, since the leak rate through a hole is proportional to the pressure across the hole. If the liquid level is below the hole, no (outward) leak will occur. At low levels of product in the tank, the influence of any water table outside the tank would also be important and could mask any leak or result in water ingress into the tank.

If a TTT is to be used in practice with a tank when the liquid level is low, it needs to be supplemented with some sort of ullage test to show that there is not a hole in the portion of the tank above the liquid level. The ullage test must also be evaluated to show that it can detect a leak rate [equivalent to] of 0.1 gph of liquid with a PD of 95% and a PFA of 5%. Often ullage tests are qualitative (meaning they do not produce an estimated leak rate, only indicate whether or not there is a leak). In this case, the non-volumetric test method must be used, requiring a minimum of 21 tests under the tight condition and 21 tests with a simulated leak, done in random order and blind to the vendor of the test.

If the TTT test matrix is to be changed to include tests at lower levels, I recommend that the 24 tests at the 90-95% level be kept and supplemented with 8 tests at the mid point and (if desired) 8 tests at the low level. In addition, it the TTT method is allowed to be used in the field at less than full, it must also include an ullage TTT for the portion of the tank above the liquid level. This ullage test must be evaluated as part of the TTT method. The ullage test generally may be less sensitive when the ullage volume is large than when it is small, so the ullage test evaluation should include tests with a large ullage volume as well as a small ullage volume.

Recommendations for ATG Evaluation Testing

I recommend maintaining the test matrix with 4 leak rates at two levels of full (90% or more) and half full.

If it is desired to test at lower that the 50% level, supplement the testing by adding 8 tests at the lowest liquid level, using the 4 different leak rates.

The rationale for these recommendations is discussed below.

The ATG protocol divides its 24 tests with 12 at the full level and 12 at the half full level. This is because it is important to demonstrate that it can function at a lower level than full. The full level corresponds to the maximum temperature effect. The half full level corresponds to the most difficult case for measuring level change for a given volume change. Some have suggested changing the design to use 8 tests at the full level, 8 at the mid point and 8 at a low level, such as 15 to 20%. I don't recommend this because the low level is the easiest test as it minimizes the temperature effect and the level change difficulty. The only concern about an ATG testing at a low level is the placement of the temperature sensors. Testing with the level below where the lowest temperature sensor is functional would not be recommended because there would be no check on thermal changes. (Since these should be small at that level, it might not be too bad, but I still wouldn't recommend it.) Consequently, adjusting the design to reduce testing at the full and mid point would make the test less rigorous. If testing at a low level is absolutely desired, I would supplement the design by adding 8 tests at the low level for a total of 32 tests. (Six tests there would probably be sufficient, but with 4 leak rates, I would opt for 8 additional tests, two at each nominal leak rate.)

The NWGLDE voted to accept and issue this guidance at its meeting on September 17, 2015.

Lamar Bradley
NWGLDE Vice Chair and ATG/ VTTT Team Leader