RESIDENTIAL UNDERGROUND STORAGE TANK STATIC TEST PROCESS

Report prepared for:

National Oilheat Research Alliance

600 Cameron Street
Suite 206
Alexandria, VA 22314

By:
John F. Donohue

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Third party validation by Calisto Bertin, PE

Residential UST Static Test Process

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1.0 **Summary**:

Manual Tank Gauging (MTG), also called static testing, is an effective, easy and inexpensive release detection method for small volume underground storage tanks (USTs). This study presents the justification and procedures to unitize MTG for leak detection in residential home heating oil tanks.

A study by the EPA shows that manual tank gauging can detect leaks as small as .2 gallons per hour (gal/h) for tanks less than or equal to 550 gallons in capacity. The same study shows that for tanks of 551 to 2000 gallons, manual tank gauging has about the same sensitivity as inventory control. These attributes make it a very appealing release detection method for small UST operators.

A review of the study, commissioned by the EPA and conducted by Midwest Research Institute (MRI) supports the stated release detection capability, but in its evaluation of the factors affecting Manual Tank Gauging capability, it provides valuable insight into measures which can easily be integrated into the MTG process which will statistically enhance reliability and increase leak detection sensitivity.

Additionally, as MTG is in essence a volumetric tank test method; incorporating and accounting for factors affecting volumetric test capabilities provides greater reliability and greater release detection capability.

This discussion also presents a range of potential problems which may occur with MTG. Their frequency, severity and impact are not necessarily equal, but are considered for the purpose of minimizing their impact when modifying application of the MTG process.

EPA defined Manual Tank Gauging as a weekly, short term, static test in which the liquid level is measured in a quiescent tank at the beginning and end of a 36 hour time period. Any change in the liquid level is used to calculate the change in volume, which is compared against established guidelines to determine whether any disagreement in measurements has sufficient significance to indicate a leak in the UST.

The discussion is intended to demonstrate the MTG process as approved by EPA for continual release detection monitoring of regulated USTs less than 2000 gallon capacity can be modified such that a regimented Static Test Process, conducted on a broad basis, will reliably identify USTs with capacities of 1000 gallons or less as being ‘tight’ or ‘suspect of leaking’. The resultant regimented Static Test Method thus provides the oil heating industry an economical, effective means to rapidly assess the underground fuel storage tanks of their customer base.

As with MTG, the process of the single Static Test involves four components: (1) Tank Gauging: the process of determining the liquid level; (2) Calibration: the process of correlating the gauge reading with the proper calibration chart to determine the volume of the product in the UST; (3) Recording: the process of accurately recording gauge results; and (4) Interpretation: the process of determining if a release from the UST is suspected.

By incorporating the fundamentals of volumetric testing, requiring a consistent level of fullness for tanks being evaluated, including a stabilization period in the process, and improving the gauging practices into the Static Test Process; increased leak detection sensitivity with greater reliability is achieved.

This discussion demonstrates leak detection of +/- .035 gph can be achieved statistically. Further, this discussion establishes the practical leak detection capability of the Static Test Process. That is, the leak detection capability within the probability of detection (PD) and probability of false alarm (PFA) criteria established by the EPA. The Static Test Process leak 'Standard' is set at the rate of +/- .055 gph for the typical residential fuel oil tank of 550 gallon capacity.

2.0 Introduction:

The oil heating industry needs a reliable, economical means to assess their customers' underground storage tanks. A percentage of these existing tanks are constructed of bare steel and were installed between 1945 and 1970. The tanks have been subject to the effects of corrosion for many years; a result of which is some of these tanks have lost integrity. Undetected fuel leaks harm the environment and can be costly to remediate.

Implementing broad based assessment programs for residential fuel tanks has been impeded by reliability of tank testing technologies and their providers, high costs and industry availability.

This discussion demonstrates that Static Testing can be implemented rapidly, requires limited capital expenditure for equipment, requires a limited level of technician training, and will reliably identify suspect tanks with more sensitive detection capability than established by the EPA.

3.0 Background:

Federal legislation in 1986 required continual leak detection for regulated underground storage tanks. The need for an economical and effective means of meeting this requirement was necessary for small regulated waste oil tanks for which other means of continual release detection were not easily achieved either due to cost or appropriateness. The American Petroleum Institute (API) conducted a study dated February 1987 on the effectiveness of static testing for used oil tanks. In the 1987 API publication Recommended Practice 1621, *Bulk Stock Liquid Control at Retail Outlets*; Manual Tank Gauging is included as a 'stand alone' release detection monitoring procedure for tanks of 550 gallon capacity or less. This publication outlines the four step process of : Tank Gauging, Calibration, Recording and Interpretation.

EPA commissioned a review of the API study. *Review of Effectiveness of Static Tank Testing* by Midwest Research Institute (MRI) was published April 1988. This report identified some flaws in the API study, identified some problems associated with static testing and also provided some solutions to increase both efficacy and accuracy of Static Testing.

EPA's publication: *Detecting Leaks: Successful Methods Step-by-Step*, incorporates some of the suggestions contained within the MRI report and provides a good overview to the manual tank gauge process. In addition to the four step process for each event listed above, interpretation of results is equated to weekly standards for volume discrepancy with monthly average discrepancies standardized.

While not being a particularly practical procedure for inclusion in the EPA Manual Tank Gauging practice, the MRI report clearly demonstrated how a single Static Test can be equally reliable as a weekly MTG program if the tank is 95% full.

4.0 Improving Detection Capability:

4.1 Level of Fullness:

Level of fullness improves leak detection capability 50%. The EPA MTG process was designed to be used on a weekly basis for tanks of any degree of fullness and tanks whose fullness would vary from week to week. A major consideration in accuracy and detection capability is the horizontal surface area of the liquid in relationship to the height of the product in the tank. The most difficult detection level is the 50% of fullness level when the horizontal surface area of the product is the largest. The smaller the horizontal surface area, the greater the detection capability. The horizontal surface area of the fluid in a cylindrical tank is smaller at the top of the vessel than at the midpoint. Therefore, by modifying the procedure to require the tank be filled to a standardized level of fullness at the time of the test, the leak detection sensitivity improves. The following example for a 550 gallon tank (48" diameter by 72" length) demonstrates the increased sensitivity of detection capability as a function of horizontal surface area relative to product level:

Table 1: Sensitivity Improvement vs. Liquid Level in Tank For a 550-Gallon Cylindrical Tank

Product Level (Inches)	Liquid Volume Change per inch at that Level	Horizontal Surface Area (Square inches)	Sensitivity Improvement
24	15 gallons	3488	0.0%
36	13 gallons	3023	13.5%
38	12 gallons	2790	20.1%
40	11 gallons	2558	26.7%
42	8 gallons	1860	46.7%
45	7 gallons	1627	54.0%

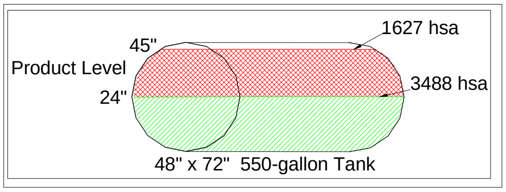

Figure 1: Horizontal Surface Area / Product Level

The Static Test Process leak detection sensitivity is improved as gallons per inch are reduced in direct proportion to the reduction in the horizontal surface area. Great improvement is not seen when comparing a tank ½ full to a ¾ full tank, but for tanks with a liquid level between 42” and 45”, an improvement of 46% to 54% in test sensitivity is achieved. While it can be argued equal detection capability can be achieved with the tank only 5% to 10% full, this is not accurate as leaks can occur anywhere in the tank shell.

The process of filling the tank insures the greatest percentage of the vessel which normally contains oil will be subject to the Static Test and provides for consistency of data in interpreting results for many tests. Effective Static Testing requires full tanks. Factors discussed under ‘Volumetric Test Considerations’ further support the full tank requirement.

Therefore, the optimum level of fullness for the Static Test Process of the typical 48” diameter tank is established to be between 42” and 45” of fullness as the improvement in leak detection sensitivity is effectively 50% while it also assures the majority of the tank shell will be subject to the test process.

4.2 Accuracy of Gauging:

Accuracy of gauging improves leak detection capability 30%. Fundamental to the Static Test Process and the leak detection sensitivity is the accuracy of tank gauging. The API report indicated a Standard Error for gauging to be 0.44”. While this may seem high, it is probably accurate when surveying a large number of owners or their designees conducting the gauging activity and the likelihood different individuals may be gauging the tank for the same MTG event. The MRI report determined requiring two gauging events averaged at the beginning and the end of each period improves the accuracy 30%. When combined with improvement resultant from minimizing the horizontal surface area, test sensitivity is significantly improved. (Additional means are discussed under ‘Section 6.1 of the proposed Static Test Process.)

Therefore, the Static Test Process requires two gauging events, with the results averaged, be conducted at the beginning and the end of the test period.

4.3 Extension of Test Period:

Extension of test period improves leak detection capability by 50%. Leak detection is expressed in gallons per hour (gph). Extending the quiet period for the tank and duration of the test, improves the gallons per hour detection capability. The EPA and MRI evaluated a time period of 36 and 48 hours for conducting manual tank gauging with the

36 hour time period being utilized in evaluation of the 0.2 gph detection standard. A 72 hour time period for conducting a static test may not have been practical for the tanks of concern to the EPA, but it is certainly a practical timeframe for evaluation of the residential heating oil tank as many of them are not in use for months at a time. (Discussion on assessing tanks while in-use is found in Appendix A.) Increasing the duration of the test period required to conduct the Static Test Process provides significant improvement in test sensitivity due to expression of the leak rate being ‘gallons per hour’ (gph).

Therefore the test period for the Static Test Process is established to be 72 hours.

4.4 Calculation of Statistical Leak Detection Capability:

Calculation of the improved Static Test Process statistical leak detection capability: EPA determined MTG met the requirement for 95% probability of detection (PD) and < 5% probability of false alarm (PFA) at a detection capability of 0.2 gph. The Static Test Process improves leak detection sensitivity by 50% due to consistency of fullness and reduction in the horizontal surface area (HAS). The Static Test Process improves leak detection sensitivity by 30% due to procedural improvements reducing the standard error of tank gauging. The Static Test Process improves leak detection sensitivity by 50% as the established test period is 72 hours.

Therefore the statistical leak detection capability of the Static Test Process is **+/-.035 gph** as calculated below**:**

Stated Leak Detection: EPA Manual Tank Gauging		0.2 gph
Multiply By: (100% - % Improvement Reduced HAS, #1)	50%	X 0.5
Multiply By: (100% - % Improvement Gauging, #2)	70%	X 0.7
Multiply By: (100% - % Improvement Test Time Period, #3)	50%	X 0.5
Statistical Leak Detection Capability Static Test Process		**+/- .035 gph**

Calculation 1: Statistical Leak Detection Capability

Additional factors, field conditions and interpretive limitations must also be considered in the development of the practical or stated leak detection capability of the Static Test Process such that the 95% probability of detection (95% PD) and the 5% probability of false alarm (5% PFA) standards established by EPA are maintained. These are discussed below.

5.0 Volumetric Test Considerations:

The Static Test Process is a volumetric test. NFPA 329: *Handling Releases of Flammable and Combustible Liquids* (1992 Edition) provides a concise overview of factors which affect the accuracy of volumetric tank methods. Namely: temperature, tank end deflection, effect of groundwater, and atmospheric concerns. [Atmospheric concerns are not considered a material factor when dealing with #2 fuel oil and a Static Test Process.] The first three factors are of concern and merit discussion as the specified

Static Test Process outlined dictates a required level of tank fullness to achieve maximum detection capability.

5.1 Temperature:

Temperature change over the course of the test can cause for an increase or decrease in product volume (and therefore level) due to thermal expansion and contraction of the product. The average coefficient of expansion for #2 fuel oil is 0.00045 gallon/degree F. Typically fuel stored below ground is considered to be at a stable temperature. Studies have shown temperature movement generally to be plus or minus 0.02 degree per hour. Although not typical; temperature rises of 0.05 degree F per hour have been recorded in periods of high warming (i.e., springtime). A 550 gallon tank 42" full contains 526 gallons. Should the temperature rise described occur during a static test, this could skew the data by 0.0118 gallon per hour, or .85 gallon over the test period as compared with the perceived normal variation of 0.0047 gallon per hour or 0.34 gallons over the test period.

An additional temperature factor is the difference in temperature between the product in the tank and the product delivered to bring the tank to the required level of fullness. This difference can be significant and product expansion (or contraction) will occur while the temperature reaches equilibrium with the product in the tank and the surrounding soils. NFPA data reports temperature changes of .02 degree F to .25 degree F per hour can occur. "*Tests have shown… when liquid is added to fill a tank for testing it will often require several days for the liquid to stabilize with the ground temperature which in itself is constantly changing.*" *Source: NFPA329, 1987: 4-3.12.3*

The MRI report generally viewed a temperature change of less than .1 degree F per hour to be of minimal significance and the effect of temperature change in this range to therefore be minimal particularly as relative to gauging error. However, this was for a test period of 36 hours, with the test period of set at 72 hours, temperature change of less than 0.05 degree F is considered to have minimal effect, but remains factored in to the practical leak detection sensitivity. The chart below compares temperature change to volume change for a volume of 500 gallons of #2 fuel oil over the 72 hour Static Test Process test period.

Table 2: Volume Change for No. 2 Fuel Oil in 72 Hours vs. Rate of Temperature Changer (1)

Temp. Change/Hour (Degree Fahrenheit)	Temperature Change in 72 Hours (Degree Fahrenheit)	Volume Change (Gallons)
0.1	7.2	1.62
0.09	6.48	1.46
0.08	5.76	1.30
0.07	5.04	1.13
0.06	4.32	0.97

Temp. Change/Hour (Degree Fahrenheit	Temperature Change in 72 Hours (Degree Fahrenheit)	Volume Change (Gallons)
0.05	3.6	0.81
0.04	2.88	0.65
0.03	2.16	0.49
0.02	1.44	0.32

Table 2: 72 Hour Gal. Change/ .1 degree F/hour

Note 1: Assumes a constant temperature change for the entire period. Volume at 500 gallons

Accordingly, while temperature will typically be of little consequence in most Static Test events, measurement and recording of ambient temperature at the beginning and end of the test period is included in the process to aid in interpretation of the results. This is discussed further in section 6.1.3 Tracking Temperature of the Proposed Static Test Process.

5.2 Tank End Deflection:

When tanks are subject to increased pressure, the flat end of the tank can push out into the surrounding backfill. The effect may be very little where the tank is supported by solid, well-compacted soil, but normal soils will compact to some degree, particularly when moist. If a 550 gallon tank is at the 12” level prior to being filled for a static test and is then filled to the 42” level; an increase of 0.93 PSI will be exerted on the tank. This will exert an increased force on the tank ends greater than 1750 pounds. The extent of tank deflection will vary based in the thickness of the steel and the condition of the backfill. The following chart shows the volume of increase of tank capacity in gallons based on the degree of deflection. This increased volume capacity in the tank can be easily interpreted as a loss of product if not adequately addressed.

Apparent Loss of Liquid Volume in Gallons
Due to Increased Pressure in a Tank

Outward Deflection at Center of Head in Inches

Deflection in Inches:	1/16”	1/8”	3/16”	1/4”	5/16”	3/8”	7/16”	1/2”
Diameter: 48”	.49	.98	1.47	1.95	2.44	2.93	3.42	
64”	.87	1.74	2.61	3.48	4.35	5.22	6.10	6.97

Underlined figure represents amount normally encountered

Table 3: Tank End Deflection (Source: NFPA 329-1992 Edition; Chapter 4, Figure Five)

Study and testing have shown that in almost all cases tank movement will occur. It will not occur suddenly as it takes time to consolidate the soils.

5.3 Groundwater Elevation:

Groundwater on the outside of the tank is exerting an inward pressure on the vessel, this is offset by the outward pressure exerted by the weight of the oil in the tank. Dependent on the two fluid levels and the relative height of both compared to the height of a hole in the tank, a tank could in fact be at equilibrium with neither a loss of product nor ingress of water. Fuel oil weighs approximately 86% the weight of water. A tank full to the 24" level is at equilibrium with a groundwater elevation of approximately 20.6" above the bottom of the tank. Tanks filled to the 42" level exceed equilibrium provided the groundwater elevation is not greater than 36" above the bottom of the tank. Should groundwater be at or near the top of the tank, water ingress can still occur. This further supports the proposed level of fullness being between 42" and 45".

Additional information on gauging for water and interpreting results may be found in Section 6.1.2 of the proposed Static Test Process.

Therefore the proposed Static Test Process requires the tank be filled to the optimum 42" to 45" level of fullness 72 hour prior to the initiation of the static test. This minimizes the effect of the two most significant factors affecting volume errors, thermal expansion and tank deflection, which could either mask or falsely indicate a leak.

The 72 hour pre-test requirement allows sufficient time for the temperature stabilization to occur, greatly reducing the risk of temperature variation. This reduces incidence of a false test result and by increasing the likelihood most temperature variation over the test period will be within the established test standard.

The 72 hour pre-test period assure tank end deflection will not be a factor during the test period and therefore does not have to be factored into the test standard.

6.0 The Static Test Process: Potential Problems and Solutions:

A detailed step by step procedure is outlined below. Effectively, the Static Test Process is comprised of four components after filling the tank to the optimum test level and after the 72 hour pre-test period has elapsed:

(1) Tank Gauging, the process of determining the liquid level;
(2) Calibration, the process of correlating the gauge reading with the proper calibration chart to determine the volume of the product in the UST;
(3) Recording, accurately recording gauge results; and
(4) Interpretation, the process of determining if a release from the UST is suspected.

6.1 Tank Gauging:
Ensure the tank is gauged properly: If the tank is not gauged properly, the liquid measurement will not be correct. API statistically demonstrated a 0.44" standard error. The review of MTG published by MRI recommended the gauging practice be the result of two consecutive gauge events averaged. This provided for a 30% reduction in the standard error. By employing this process the standard error is approximately 0.25" for

the Static Test Process. Many factors will affect proper gauging; care of the tank stick, proper placement in the tank, maintaining a vertical position and avoiding 'slant'.

To properly gauge a tank, the tank must be 'quiet'. For fuel oil tanks this requires the equipment be off, to minimize any 'tank wave' caused from fuel entering the tank via the fuel oil return line piping. The tank stick should be gently lowered into the tank through the oil tank fill pipe, maintaining a vertical position, until the tip touches the tank bottom, then immediately withdrawn. Gauging for water does not occur at this time. The stick should be inserted at the same point in the oil fill each time it is gauged. (A reference point can be drawn on the fill box with a permanent marking pen to aid in alignment of the stick so it is placed at the same location at each gauging event.) The tank stick must be long enough to reach the tank bottom without the use of extensions or strings. (Folding tank sticks may be convenient, but are not appropriate for conducting Static Testing.) The tank stick should not rest on a projection at the tank bottom. After the gauge stick is withdrawn, read (data recorded) and the tank stick wiped clean, the process is completed a second time with the second reading recorded. The average of the two readings is the test 'start level'. At the end of 72-hours the process is repeated.

Since the gauge levels are the average of two consecutive gauge events; errors in stick placement or reading of stick should be readily apparent if the level differs by more than ¼". In this case, a third gauge event should be conducted to affirm the more accurate reading.

Care should be taken to avoid damaging tanks when gauging. The tank stick should be wood and slowly lowered in tank.

6.1.1 <u>Ensure Accuracy of Reading</u>:
Stick readings are required to be to the nearest ⅛". The edge of the stick adjacent to the graduated side should be grooved at each increment to prevent 'product creep'. (Product moving up the stick past the measured level) The use of product finding paste is recommended to improve accuracy of gauging. Product finding paste aids in adherence of product to the stick, reduces product 'creep' and provides a visual aid in determining the level.

Product paste should be applied in a thin layer on a side of the stick adjacent to the calibration. Coating the stick between the 38" level and 42" level is suggested. The mark left by the paste, the 'cut' is read on the calibrated side. The paste needs to be applied for each stick reading taken.

6.1.2 <u>Determine Presence of Water in the Tank</u>:
For the purpose of Static Testing, water level and product level can not be gauged simultaneously. Proper product level gauging requires immediate withdrawal of the tank stick after gently touching the bottom of the tank. Most water finding pastes require a residence time for detection. API states this is typically 20-30 seconds for distillate products.

The presence of water does not necessarily indicate a leak if detected during the start gauging event as water can be an accumulation due to condensation or water separation from the fuel. A change in level over the 72-hour Static Test may indicate the presence of a leak in the UST system and must be evaluated. Accurately gauging for water is equally critical as gauging for product. After product gauging is completed, the bottom three inches of the tank stick should be coated with a thin layer of water finding paste. The stick should be slowly lowered into the tank until it gently touches the bottom, the stick then rests on the bottom of the tank for 30 seconds. The stick is extracted and read. If no water is detected, this is recorded on the test form. If water is detected, (or was detected at the test start) the process is repeated with each reading recorded and then averaged to determine the change in water volume.

If water is detected in the tank, but a change in water level is not detected through the test period; good tank maintenance practice dictates action should be taken to remove this water from the tank.

6.1.3 Tracking Temperature:

Since the Static Test should not commence until 72 hours after the required fuel delivery was made, and since no product enters or leaves the tank during the Static Test period, the effects of temperature change should be limited to only the change in ambient temperature.

Recording ambient temperature at the beginning and end of the test period is essential for aid in analysis and interpretation of the test result. As was previously discussed, wide temperature changes can either mask a leak as product expands, or falsely indicate a leak if product contracts. The change in ambient temperature can be monitored through a means as simple as placement of a thermometer in the area of the tank at each gauge event and recording the temperature. Use of a hand-held, infrared remote temperature sensor can also be employed to measure the temperature of the surface of the oil in the tank.

It is suggested the start and end Static Test gauging events occur during the same time period of the day to help minimize effects of temperature. This will help minimize effects of daily temperature swings (AM vs. PM) and differences in sun exposure which can occur over the day.

If a significant temperature fluctuation could have occurred within the vessel as indicated by the change in ambient temperature an approximate determination of the volumetric effect can be made using the following:

Tank volume (in gallons)
Multiply By: Co-efficient of Expansion, .00045
Multiply By: Change in Temperature (degree F)
Equals: Volume Change (in gallons)
Divide By: Static Test Elapsed Time (in hours)
Equals: Gallons per Hour (gph) due to Temperature Change

Calculation 2: Effect of Temperature Change over Static Test Period

The measured change in temperature can also be compared with the data contained in Table 2, on Page 6. If the potential for a change in product temperature of greater than five (5) degrees exists, the potential change in volume is greater than one (1) gallon with the corresponding level change potential being greater than ⅛” inch.

6.2 Calibration:

The tank chart is used to convert tank level in inches to volume in gallons. The accuracy of the chart, the correct chart for the tank being tested, verification of tank size, and chart calibration to ⅛” increments are all integral to successful Static Testing.

The tank manufacturer typically provides charts specific to the tank size. For fiberglass tanks, this is the best resource. Steel tanks are typically manufactured in standard sizes, but the charts are not typically calibrated to ⅛” increments. A tank chart program is available for download on the Steel Tank Institute website (www.steeltank.com).

Use of the tank chart software requires imputing the actual diameter and length of the particular tank. Tank size can be verified by taking measured ‘before’ and ‘after’ inches readings at the time the tank is being filled to the optimum Static Test level and then comparing the metered gallons to the volume change calculated from the change in level. Tank diameter and length can also be field verified. Verification is suggested only to assure a false result for the Static Test is not obtained due to assumption of tank size and a resultant comparison with the incorrect standard.

If the only available chart for the tank is calibrated in ‘whole’ inches, API publication 1621 includes a procedure for determining volume to the nearest ⅛”.

Example of the method for a 550 gallon tank with a level of 41 and 5/8”

Tank volume at 42”	526
Tank volume at 41”	516
Difference (526-516=)	10
Divide by 8 (10 / 8 =)	1.25
Multiply by increment (1.25 * 5 =)	6.25
Add to Tank at LOWER inches (516 + 6.25 =)	522.25 Gallons

Calculation 3: API Inches to Gallons Volume Conversion

6.3 Recording:

Proper recording of tank gauge data is essential to an effective Static Test process. Static Test forms need to provide for recording of each tank gauge event for both product and water at the beginning and end of the test period.

Forms must include the measured levels, the average level and the gallon equivalent. The date and time of the gauging events, along with description of weather condition and ambient temperature is necessary.

The form must include a final comparison from the beginning of the test to the end of the test period with the change in volume converted to gallons per hour.

Provision for the site and customer information along with the company and technician conducting the test is also important. A copy of the test data should be retained by the customer on-site.

6.4 Interpretation of the Data:

The change in gallons over the test period must be compared to a 'Standard' to determine if the tank meets the test requirement or could be suspected of leaking. The 'Test Standard' can be expressed in either gallons or inches. Interpretation of Data must also include interpretation of test validity.

Mathematically the potential to determine leaks as small as 2.52 gallons (.035 gph * 72 hours) has been demonstrated. For the tanks subject to this discussion this equates to a level change of generally ¼" and ⅛" for 550 gallon tanks and 1,000 gallon tanks respectively. This is equal to or less than the determined Standard Error of gauging. Improvement in the Standard Error of tank gauging is promoted with the use of trained technicians, use of product finding paste, recording of ambient temperature and gauging for water. However the variable of human error, effect of temperature and absolute uniformity of product fullness level cannot be completely overcome. In order to maintain a Probability of Detection (PD) of 95% with a Probability of False Alarm (PFA) of 5%, tolerance for these variables must be factored into the Test Standard.

Therefore, the standard for meeting the Static Test criteria is 4 Gallons over the test period. This is based on the following:

6.4.1 Standard Error of Gauging:

Even with improvement in gauging practice and use of trained technicians improvement beyond a .25" (+/-⅛") Standard Error is unlikely. For tanks 550 gallon tanks full to between 40" and 45" this equates to a +/- 1.0 gallon standard error or +/-0.014 gph.

6.4.2 Temperature:

It is demonstrated earlier periods of high warming or cooling could impact volume over a 72 hour period by up to 0.0118 gph where a 0.05 degree F per hour temperature change occurs over the 'Static Test Period'. Use of evaluating ambient temperature reading to validate minimal variation during the test period is important, but over 72 hours a temperature change of +/- 1 deg.F remains a potential not easily measured. This equates to a variation of +/-.225 gallons or +/- .003 gph. (500X.00045/72)

6.4.3 Chart Calibration:
The tank chart, calibrated to ⅛" increment, is in whole gallons and the average ⅛" volume change for tanks between 40" and 45" full is one gallon. Accordingly, 2.52 gallons over 72 hours becomes either 2 gallons or 3 gallons. This equates to a variation of +/- 0.5 gallons, or 0.007 gph (0.5 gallons / 72 hours).

Therefore, a tolerance of +/- 1.725 gallons could be attributed to test variables and physical limitations of the equipment and tools employed in conducting the Static Test Process. This tolerance, added to the statistical leak detection sensitivity of +/- 2.52 gallons establishes the practical leak detection sensitivity or Test Standard at +/- 4.245 gallons. As the chart calibration is in one gallon increments at the level range specified for the Static Test Process; 4 gallons is the established Test Standard as it is the discernable level which indicates a tank as suspected of leaking.

Static Test Standard

	Change Inches	Change Gallons	Leak Rate per Hour
550 Tank	.5 inches	4 Gallons	.055GPH
1000 Tank	.5 inches	7 Gallons	.097GPH

Table 4: Static Test Process Standard-Inches and Gallons

6.5 Static Test Process-Test Validation:
Of equal importance to the interpretation of data and comparison with the 'Standard' is the evaluation of the individual Static Test conducted to assure protocol conformance prior to prescribing a recommended course of action. The primary areas of review include: excessive variation in stick readings and averaging employed, measured change in water level, temperature change greater than six (6) degrees F, and elapsed time of test. Discrepancies in any of these areas could invalidate the test results.

Data Interpretation / Prescribed Action

Level Change Temp. Change +/- < 5 degF	Plus or Minus ¼", (or less) No Change in Water	Leak Not Suspect
Level Change Temp Change +/- < 5 degF	Plus or Minus ¼" (or less) - Change in Water	Determine Cause of Water Change- Repeat Test
Level Change Temp Change +/- < 5 degF	Plus or Minus ⅜", No Change in Water	Repeat Test*

Level Change Temp Change +/- < 5 degF	Plus or Minus ⅜" - Change in Water	Determine Cause of Water Change- Repeat Test
Level Change Temp Change +/- < 5 degF	Minus ½"	**Tank Suspect- Certified Testing Required**
Level Change Temp Change +/- < 5 degF	Plus ½" – No Change in Water	Repeat Test*
Water Change	Plus or Minus ⅛", No Product Level Change	Repeat Test*
Water Change	Greater Than ⅛" with Product Level Change	**Tank Suspect- Certified Testing Required**
Temperature Increase > 5 degree F.	Level Change Increase	Repeat Test* or Utilize Calculation 2, Page 9
Temperature Increase > 5 degree F.	No Level Change or Change of +/- ⅛"	Repeat Test*
Temperature Increase > 5 degree F.	Level Decrease ¼ " or more	**Tank Suspect- Certified Testing Required**
Temperature Decrease > 5 degree F.	Level Change Decrease	Repeat Test* or Utilize Calculation 2, Page 9
Temperature Decrease > 5 degree F.	No Level Change or Change of +/- ¼ "	Repeat Test*
Temperature Decrease > 5 degree F.	Level Decrease ½ " or more	**Tank Suspect- Certified Testing Required**

Table 5: Data Interpretation/Action

- Repeat Test Recommendation - Gauging errors are random and it is unlikely they repeat. A repeated level decrease of ⅜" indicates a Suspect Tank. In other cases, results due to gauging errors in either water level or product level will not repeat when tank is retested. Likewise, it is unlikely excessive temperature change will re-occur in subsequent tests. The second result can thus be compared with the 'Test Standard' provided temperature change during second Static Test remains less 5 degrees F.

7.0 Conclusion:

The Static Test Process is an effective method for determining if residential fuel oil tanks with capacities of 1,000 gallons or less are 'tight' or are 'suspected of leaking'. When incorporated with an annual tank maintenance program, the Static Test Process can be a valuable tool for providing annual release detection monitoring of the residential fuel oil UST.

The Static Test Process is a comprehensive extension of the EPA Manual Tank Gauging process which provides 0.2 gph leak detection for tanks of 2000 gallon capacity or less. Through incorporation of improved gauging techniques, standardization of the process through mandating a required level of fullness, compensation for variables inherent in volumetric testing through inclusion of a pre-test stabilization period leak detection sensitivity is improved by nearly 75% providing a leak rate capability of .055 gph while maintaining the required PD of 95% with a PFAof 5%.

The Static Test Process is a volumetric precision test, which requires a rigorous protocol be followed. To assure adherence and reliability of the process, training and certification of existing technicians in the industry is imperative.

The Static Test Process as designed provides an economical solution in that it provides a means to reliably assess a large number of underground storage tanks which have been ignored for a long period of time.

Currently, residential fuel oil tanks are assessed only if a problem is suspected or a real estate transaction is pending. The Static Test Process, employed over the residential fuel oil tank base, provides a means to proactively assess and annually monitor a large number of tanks thus enhancing early detection of suspect tanks.

The Static Test Process is proposed as a means to easily identify the tank suspected of leaking. Further investigation of the suspect tank can then be undertaken to finitely determine if a release has occurred or if the potential to leak exists with the subject tank.

Sources:

American Petroleum Institute. 1987. *Recommended Practice 1621, Bulk Stock Liquid Control at Retail Outlets.*

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U.S. EPA. 1988. *Review of Effectiveness of Static Tank Testing*. Report by Midwest Research Institute for Office of Underground Storage Tanks, U.S. EPA. (pub#510K92810)

U.S. EPA, NJDEP. 1996. *Manual Tank Gauging for Small Underground Storage Tanks*

NFPA. 1987,1992,1999. *Recommended Practice 329. Handling Underground Releases of Flammable and Combustible Liquids.*

Appendix A: Testing Lines with the Static Test Method:

As thus far described the Static Test process is for fuel oil tanks which are not in-use during the Static test period. Some fuel oil tanks are in-use year round as hot water is produced by the heating oil equipment. Further, in a small number of case, discharge from residential fuel oil tanks are resultant of failure of the product bearing piping, namely the fuel oil supply line (FOS) and the fuel oil return line (FOR). FOS generally operate under suction therefore, mechanical problems with the operation of the equipment provide early detection of a FOS failure. Failure of the FOR is generally less noticeable as these lines are returning excess fuel from the pump to the tank.

One means of conducting the Static Test at a site where providing a continued supply of fuel oil to the heating equipment is needed is use of a temporary tank of sufficient capacity to store the 72-hour fuel requirement. Once the alternate supply is in place, and proper fullness of the tank is achieved, the Static Test can commence.

Another consideration is use of an oil metering device on the supply line. The beginning and end meter readings can be recorded, and the difference subtracted from the observed change in volume in the tank detected over the Static Test Period.

While this alternative provides the benefit of assessing both the tank and the lines during the Static Test, some additional factors must be discussed. The effectiveness of a single static test is dependent on level of fullness, therefore subject tank should be filled to a minimum of 45” prior to the stabilization period, and generally should consume no more than six gallons per day. Usage greater than this reduces the tank level at the conclusion of the test to a point where the ¼” gauging error effectively reduces the Static Test accuracy by 50%.

If a fuel metering gauge is to be utilized during the Static Test, the time on-site will be extended, the fuel meter must be installed, immediately after which the equipment must cycle to be certain the lines are restored to their normally full state. Subsequent to this, the unit must be shut down for a 15 minute interval to be certain the tank is ‘quiet’ so the gauge event is not affected by ‘tank wave’ from the flow of product. Accordingly, at the end of the test period; the equipment must again be shut off with the tank allowed to stabilize prior to the gauge event.

After the two gauge events and the comparison of data, result interpretation must factor in reliability of the meter. Most fuel meters specify an accuracy of +/- 1%, but this is only if the flow meter is operating at peak curve flow. Flow rates at the low end of the meter’s operating range may have a variance of as much as +/- 5%. Also, the meter should be calibrated to .1 gallons. The effect on the detection capability of the Static Test can be as much as .014 gph if the meter is calibrated to 1 gallon increments and by an additional .0125 gph if the meter is 5% off.

The additional benefit of testing the product lines must be seriously weighed against the loss of detection capability when a fuel supply meter is used and product level is reduced during the Static Test Period even though leak detection of =/- .1 gph is still achieved.

Static Test Standard
(with Fuel Meter)

	Change Inches	Change Gallons	Leak Rate per Hour
550 Tank	1.0 inches	7 Gallons	.097 gph
1000 Tank	1.0 inches	13 Gallons	.180 gph

Table 6: Static Test Process Standard w/Fuel Meter-Inches and Gallons