



Introduction to Statistical Inventory Reconciliation (SIR) For Underground Storage Tanks

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Why it is Important to Read This Booklet

Federal and Pennsylvania laws require underground storage tank (UST) systems to have release detection. One of the available release detection methods is Statistical Inventory Reconciliation (SIR). In this method, a trained professional uses sophisticated computer software to conduct a statistical analysis of inventory, delivery and dispensing records.

It should be noted that, in Pennsylvania, SIR methods do not meet the release detection requirements for USTs that were installed after November 10, 2007, or any UST that stores a hazardous substance. These UST systems are required to perform interstitial monitoring at least once every 30 days. SIR may be performed in addition to interstitial monitoring.

SIR may allow the owner or operator of a UST facility with petroleum product USTs installed on or before November 10, 2007, to meet release detection requirements without an extensive outlay of capital, using only the equipment that most facilities have readily at hand – a gauge stick and a tank chart used for inventory control. The SIR analysis itself is usually provided as a service by vendors who charge a monthly fee based on the number of tanks analyzed.

This booklet provides basic information on the method – what it is, how it works, factors that have an impact on data quality – to assist in determining if SIR is appropriate.

Additional Information on UST Release Detection

For information on release detection requirements for USTs in Pennsylvania and the various methods of release detection available to you, see Storage Tank Program fact sheets 2630-FS-DEP1449 “Release Detection: Meeting the Tank Requirements” and 2630-FS-DEP1507 “How to Detect Releases in Underground Piping Systems,” available on the Department of Environmental Protection’s (DEP) website (www.dep.pa.gov, Businesses > Land > Storage Tanks), or call the Division of Storage Tanks’ toll-free customer service line at 1-800-42-TANKS (in Pennsylvania) or 717-772-5599 (local and out of state).

Other sources of information on USTs and release detection methods include:

- The United States Environmental Protection Agency (EPA), Office of Underground Storage Tanks. Visit their website at www.epa.gov/ust.
- The New England Interstate Water Pollution Control Commission (NEIWPCC): www.neiwpcc.org/ust.asp.
- The National Work Group on Leak Detection Evaluations (NWGLDE): www.nwglde.org/.

How Does SIR Work?

At first glance, SIR looks very similar to old-fashioned inventory control – the owner or operator, using simple equipment, tracks tank product volumes, deliveries and sales. However, the similarity ends there. Simple inventory control is relatively imprecise; and, depending on the system throughput, the owner could be losing hundreds of gallons every month without realizing anything is wrong.

By contrast, SIR analysis can be very sensitive and accurate. An SIR vendor can take the same inventory data and analyze it for small releases that would go unnoticed with inventory control. By using a month's worth of good tank data, it is possible for SIR methods to detect a release of 0.2 gallons per hour – which is equivalent to just over 1½ pints per hour (about 145 gallons per month) – from a tank or its product lines, 95 out of 100 times. All monthly release detection methods must be certified by a third-party tester to meet this **performance standard**.

The mechanics of how SIR works are beyond the scope of this booklet. SIR vendors actually use a variety of statistical tools to evaluate inventory data. No two vendors' methods are exactly alike, and the information they collect and the results they provide can vary. Still, for fundamental release detection purposes, there are only three possible, bottom-line responses for any SIR test – **PASS**, **FAIL**, or **INCONCLUSIVE**. These bottom-line responses (described below) are the only allowed responses in Pennsylvania.

PASS – According to the analyzed data, the UST system is not releasing a detectable amount of product.

FAIL – Analyzed data indicate a loss of product from the system or an influx of groundwater. However, a **FAIL** does not *necessarily* indicate that the system is leaking. A **FAIL** may be due to miscalibrated dispenser meters, inaccurate delivery records or stolen product. There is also a chance that a **FAIL** is a false alarm.

If the owner receives a **FAIL**, investigate the problem as a suspected release. Within seven days, determine the reasons for the **FAIL** (follow the procedures on page eight). Document and retain a record of the investigation. Call the appropriate DEP office (see inside back cover for phone numbers) to report a leaking UST or the inability to determine the cause of the **FAIL**.

INCONCLUSIVE – There is insufficient data to analyze or the data quality is too poor to make a pass/fail call. There is a chance that the information provided to the SIR vendor is so flawed that it is not possible to make a determination. This often can be traced back to poor tank sticking or bookkeeping practices (for example, a new hire who has received inadequate training).

Whatever the reason, an **INCONCLUSIVE** result means that the owner has failed to perform acceptable release detection on the UST in question for that month. The owner is in violation of Pennsylvania and federal release detection requirements. Follow the procedures on page eight for investigating a suspected release. Document and retain a record of the investigation. If the problem cannot be located and corrected within seven days, report this to the appropriate DEP regional office (phone numbers inside back cover).

Necessary Equipment

One of the major attractions of SIR for UST owners and operators is that it does not require a large, up-front investment of capital – the primary cost is subscribing to the SIR vendor's services. The equipment needed to use the method is already present at most UST facilities.

SIR vendors cannot perform their services adequately unless they know what equipment is at the facility. Each service provider begins by asking the owner to fill out a short form that lists the equipment at the facility. It must be complete and accurate. One area that is commonly incomplete and causes many problems is the information on blended and siphoned tank systems.

Gauge Stick or Other Gauges

A gauge stick, made of wood or other non-sparking material, is used to measure the depth of liquid in the UST. Typically, such sticks are marked or notched in 1/8-inch increments starting at the bottom of the stick. It is important that the stick be in good condition. Sticks that have worn ends, cut-off ends, worn-off numbers or worn-off varnish coatings are not acceptable and should be replaced.

Other forms of liquid measuring devices can be used if they are available and in good operating condition. Automatic tank gauges (ATGs), for instance, can simplify measuring tank volumes. (Keep in mind, of course, that some ATG's can, by themselves, serve as an acceptable monthly release detection method for the tank).

Whatever form of gauge used, the owner must follow the SIR vendor's instructions carefully and completely to gather useful data. For instance, many providers of SIR services require that the tank liquid-level measurements be made to the nearest 1/8-inch. If the owner fails to follow the vendor's instructions, they are out of compliance for leak detection and may end up with inconclusive test results.

Pastes for Finding Fuel or Water

If using a gauge stick, improve the quality of the readings by using a fuel-sensitive paste smeared over about six inches of the stick at the expected fuel level. The paste changes color where it comes into contact with the fuel and can make it easier to determine the level.

Similarly, use a water-sensitive paste on the end of the stick to monitor for the presence of water in the bottom of the tank. While water in the tank can come with product deliveries or result from the condensation of moisture inside the tank, it can also come from groundwater leaking in through holes or through loose fittings near the top of your tank. Water-sensitive paste can be affected by moisture in the air. Discard paste that is already discolored.

To prevent water from damaging the tank or affecting the quality of the product, any significant accumulation of water should be removed in accordance with the tank manufacturer's recommendations and product supplier's guidelines. Water accumulation may not exceed two inches in petroleum product USTs in Pennsylvania.

Note: Special pastes are needed to obtain acceptable gauge stick readings for ethanol blended fuel.

Tank Chart

The strapping chart used to convert stick measurements into gallons must be the correct one for the tank being gauged. The chart should have stick measurements listed to each 1/8 – inch to minimize math errors that occur when using charts marked off in larger increments – for example, only to the nearest inch. SIR vendors can quickly determine if the chart is inappropriate to the tank and will often generate a proper one.

Calibrated Dispensing Meters

A poorly calibrated totalizer meter can produce flawed, inaccurate data that may be mistaken for some types of releases. While many SIR vendors can identify this pattern as a possible cause of a *FAIL*, it is wise to avoid the problem entirely. Keep your dispensers in good operating condition, and have them periodically recalibrated as recommended by the equipment manufacturer or as required by state and local weights and measures agencies.

Forms

The SIR vendor typically provides forms on which daily stick readings, sales and deliveries are recorded. These forms often resemble the inventory sheets usually maintained at UST facilities. In some instances, SIR vendors may allow submission of the data on a facility's own inventory sheets. Some vendors also permit submission of data in electronic format, such as computer spreadsheets.

SIR Reporting and Recordkeeping

What the Owner Should Provide to the SIR Vendor

Although SIR vendors may ask for a variety of information, some of the more common elements include:

- Tank size (capacity, diameter and length)
- Tank type, material of construction and manufacturer
- Product type
- Tanks that are siphoned together
- Tanks that are blended together and the blending ratio
- Date each stick measurement was taken
- Daily opening stick measurement and volume
- Daily closing stick measurement and volume
- Daily sales volume
- Gross (uncorrected) delivery volumes over the course of the month
- Thirty days of observations - Consult the vendor concerning the minimum number of readings required if the facility does not operate seven days a week. Some can provide a valid analysis on as few as 22 days of operating data.

What the Vendor Should Provide to the Owner

Vendors supply different levels of service to their clients. Consult with individual vendors to find the collection of features desired. However, there is a core of reporting elements that should be common to all SIR analyses (see sample on page 7). These elements include:

- A third-party certification that indicates their method is usable for your tank systems. Keep this certification so that it will be available for inspectors as long as this method of release detection is used.
- Clear and timely reporting of results in terms of *PASS*, *FAIL*, or *INCONCLUSIVE*. Pennsylvania requires vendors to provide reports to the owner **within the thirty-day monitoring period**. Owners must provide their data to the vendor in a timely manner to get the report back within the required time frame.
- Complete and annotated copies of inventory records used in the analysis, showing such problems as errors in delivery records or bad measurements tossed out by the tester.
- Suggestions as to the likely cause of any test failure or inconclusive result.
- Instructions on follow-up actions to be taken in the event of a *FAIL* or *INCONCLUSIVE* (for example: "Within seven days: determine the reason for the *FAIL*; report a leaking UST within 24 hours to your local DEP regional office").

For quantitative SIR testing methods (the only type of SIR analysis permitted for UST release detection in Pennsylvania), the form must report (in gallons per hour) the calculated leak rate, the minimum detectable leak (MDL) rate, and the leak threshold at which a leak would be declared based on the data provided for each tank. See page 10 for more information on leak rates and thresholds.

The SIR vendor may supply other useful information and services beyond the basics itemized above, including:

- Offsite storage of leak detection records
- Potential reasons for a *FAIL* other than a release of product:
 - Apparent product theft
 - Missed product delivery entry
 - Suspected totalizer miscalibration
- Potential reasons and possible solutions for any *INCONCLUSIVE* results
- Possible location of a leak within the system
- Assessment of tank sticking practices
- Special tank-specific strapping charts for those tanks needing them (such as tilted tanks and odd-sized tanks)

What to Keep on File

The minimum recordkeeping requirements for facilities using SIR are the same as for other release detection methods:

- All written performance claims and a third-party certification pertaining to the specific SIR method used. Written justification for performance claims and/or a description of how they were tested or determined by the vendor. Keep these documents on file for the entire time the SIR method is used. The documents will be examined during each facility operations inspection to ensure you are using a valid release detection method.
- The monthly SIR reports, along with the results of any other sampling, testing or monitoring. To demonstrate that the owner is performing proper monthly release detection, these records must be available for, at minimum, the last 12 months the tank system contained product.
- Records of equipment calibration and maintenance must be kept for at least one year. Any schedules of required calibration and maintenance provided by the SIR vendor or other equipment manufacturer (for example, an ATG) must be kept for the entire time the method or equipment is used.
- Records (steps taken and results) of the investigation(s) into each *FAIL* or *INCONCLUSIVE* monthly test result. Keep the record of the investigation with its corresponding SIR report. At least the last 12 months of records should be retained and made available to DEP or to third-party certified inspectors during facility inspections.
- Records of the walkthrough inspection(s) conducted at a minimum of every 12 months for any handheld release detection equipment (gauge stick) used for recording SIR data **OR** records of the annual periodic testing of electronic and mechanical components of monitoring equipment (for example, an ATG) used for recording SIR data.

Sample Cover Sheet of a Quantitative SIR Report

Monthly Statistical Inventory Reconciliation Report

Sammy's SIR Services
12739 N. South St.
Nowhere, USA 00000

**November
2019**

For the Period of: November 1-30, 2019
Facility: Alicia's Pit Stop
123 E. Third Street
Any Town, PA 19999

Required, simple, concise
description of system status.

Tank ID	Product	System Status	Measured Leak Rate	Threshold	MDL
001	Premium Unleaded	PASS	0.037	0.09	0.18
002 ¹	Regular Unleaded	FAIL	0.735	0.13	0.26
003 ²	Diesel	INCONCLUSIVE	0.120	0.17	0.34

(All rates are in gallons per hour)

¹ Tank number 002 has an unexplained loss of product. You must complete steps to confirm or refute a release within 7 days. A confirmed release must be reported to your local DEP regional office within 24 hours of confirmation.

² Tank number 003 could not be analyzed to the necessary performance levels. The tank has failed to meet Pennsylvania release detection requirements for the period in question. Improved tank gauging methods may help. See the report detail for more information. An investigation into the possibility of a release must be completed within 7 days. Inability to determine that a release has not occurred must be reported to your local DEP regional office.

What to do if problems
are discovered.

Detailed copies of
inventory records are
included.

Copies of your analyzed inventory records accompany this report.

Keep this report on file for at least one year.

Questions? Call XXX XXX-XXXX.

Number to call for help.

What to Do When the Owner Gets a ‘*FAIL*’

When the UST system fails an SIR monthly analysis, it is considered a ‘suspected release.’ Investigate the cause of the failed test. Within **seven** days, determine the cause of the *FAIL* and correct it, if possible. On the basis of the test results, the SIR vendor may be able to provide areas to examine, such as a miscalibrated totalizer. Repair or replace defective equipment immediately.

If the *FAIL* cannot be linked to equipment problems, have the UST system (tank and piping) tightness tested or the site checked for evidence of a release (such as sampling in the excavation zone). If a release is confirmed, contact the appropriate DEP regional office immediately. A confirmed release must be reported to the appropriate DEP regional office **no later than 24 hours** after determining that the release occurred.

Document the actions taken to investigate the cause of the *FAIL* and the results of those actions. Retain this record for the operational life of the UST system and a minimum of 1 year after the UST system has been permanently closed.

What to Do When the Owner Gets an ‘*INCONCLUSIVE*’

An *INCONCLUSIVE* means the owner has failed to meet release detection requirements for the month, and is considered a ‘suspected release.’ An *INCONCLUSIVE* should be investigated in the same manner as a *FAIL* test result, including having the tank and piping tightness tested. If the owner cannot determine and correct the cause of the *INCONCLUSIVE* within **seven** days, call the appropriate DEP regional office. A list of DEP regional office phone numbers can be found in the back of this booklet. In some instances, the owner may be required to perform additional system testing or soil sampling to be sure the UST is not leaking.

An *INCONCLUSIVE* should not be taken as demonstrating the failings of a given vendor’s method – it is inherent to all methods. Even if vendors use terms in their literature other than “inconclusive” - such as “investigative loss” – they represent the same condition and must be investigated in this same manner.

In all cases, double-check the operating procedures to see what caused the *INCONCLUSIVE*, and then prevent its recurrence. The SIR vendor may provide assistance in locating the problem and may offer suggestions to improve the data collection.

Document the actions taken to investigate the cause of the *INCONCLUSIVE* along with the results of those actions. Retain this record for the operational life of the UST system and a minimum of 1 year after the UST system has been permanently closed.

Answers to Frequently Asked Questions

“Can SIR be used on manifolded tanks?”

Certain SIR methods can be used on tank systems that have multiple tanks linked together by siphon bars when the specific method has been tested and proven to work on these systems. The third-party certification will indicate when this is acceptable, including the maximum number of tanks and total system capacity for which the method can be used.

The vendor's procedure generally requires that each tank in the manifolded system be individually gauged for inventory measurements. As with single tank systems, no product deliveries or sales should be made during the time the sticking and totalizer readings are taking place. In all cases, follow the vendor's instructions as closely as possible to reduce the possibility of an '*Inconclusive*.' Ensure that the vendor is aware the tanks are manifolded.

“Can SIR be used on a blended system?”

Some SIR providers are able to analyze blended systems satisfactorily. They may analyze the tanks separately (recommended) or as one large system (allowed, but not recommended). When analyzed as one large system, the total of the tank storage capacity listed for manifolded tanks on the third-party certification, and any other listed restrictions, must not be exceeded.

“Why did SIR vendor fail my tank for a leak under 0.2 gph?”

First, it is a misconception that any leakage into the environment is acceptable. Even small leaks over long periods of time can result in extensive contamination that can cost substantial time and money for soil and groundwater cleanup. An intermittent, pencil-lead sized stream can release up to 2,200 gallons per month into the environment.

Second, the performance standard by which release detection methods (including SIR) are measured indicates that leaks of 0.2 gph must be detected 95 out of 100 times. Further, false alarms should not happen more than five times in 100 analyses. What this means is that the SIR vendor looks at the estimated leak rate determined for a tank – say 0.15 gph – and asks, “What is the likelihood that the *true* leak rate is actually 0.2 gph?” On the basis of a statistical analysis of the data provided, the vendor can make the call as to whether or not the system tests tight. The better the data provided, the smaller the release that the vendor can detect, and the sooner the owner can stop a release before it becomes a serious problem.

Typically, a *FAIL* will be declared for apparent releases of around 0.1 gph. See the question on the next page on ‘estimated leak,’ ‘threshold’ and ‘MDL’ for additional information.

“What is the difference between ‘qualitative’ and ‘quantitative’ SIR methods?”

Although there are many methods that are employed by vendors performing SIR analyses, they break down into two major classifications: *qualitative* and *quantitative*.

Qualitative methods do not provide estimated leak rates. When a vendor's qualitative method is evaluated to demonstrate its capability of meeting the EPA performance standard, it simply reports results in terms of *PASS*, *FAIL*, or *INCONCLUSIVE*. These results are compared with the evaluator's knowledge of which tanks are leaking in a test set of tank records.

Qualitative methods are not permitted for UST release detection in Pennsylvania.

Quantitative methods also categorize results in terms of *PASS*, *FAIL*, or *INCONCLUSIVE*, but they go further by actually providing a numerical estimate of the leak rate, typically in gallons per hour (gph). In evaluating the performance of the method, the third-party evaluator compares the method's estimates with the actual leak rates represented in the tank test data records given to the vendor for analysis. To be acceptable in Pennsylvania, leak rates must be unknown to the vendor before the analysis is conducted.

“What are ‘estimated leak rate,’ ‘threshold’ and ‘MDL’ all about?”

These are rather technical statistical terms used by quantitative SIR vendors to provide their clients with more detailed information on their analyses. They provide insight beyond the simple *PASS*, *FAIL* and *INCONCLUSIVE*; including just how bad a leak appears to be (estimated leak rate) and the quality of the data provided to the vendor for analysis (MDL – minimum detectable leak). These numbers are required to be reported in Pennsylvania to ensure that each analysis meets regulatory requirements.

The **estimated leak rate** is the number a quantitative SIR method calculates for the amount of product your tank appears to be losing or gaining. The number is usually expressed in gallons per hour (gph), since the EPA and DEP regulations both use those units.

This estimated leak rate is rarely, if ever, zero. All tanks, whether leaking or tight, will generally show a leak rate. The question is whether this leak rate is significant. This is where the threshold comes in.

The **threshold** is basically an action level leak rate. That is, if the estimated leak rate exceeds the threshold leak rate, the SIR vendor declares a *FAIL*. It is important to note that the threshold is *not* a fixed number, such as 0.1 gph. Instead, it is typically the value associated with a fixed percentage set to the probability of false alarms (that is, declaring a leak on a system that is actually tight) the SIR vendor is willing to accept. Both DEP and EPA regulations allow no more than five percent (equivalent to one in twenty) of analyses to be false alarms. However, many SIR vendors consider one false failure in twenty analyses to be too high, and set their thresholds to a one percent probability of false alarm (P_{FA}).

Finally, the **MDL** is the **Minimum Detectable Leak** and is the smallest leak rate the vendor can determine for the data provided with a probability of detection (P_D) of 95 percent or better. The MDL is tied to the vendor-chosen P_D and the threshold and is usually twice the threshold leak rate. The MDL must be less than or equal to the EPA/DEP performance standard rate of 0.2 gph at a P_D of 95 percent and a P_{FA} of five percent in order to make a valid *PASS/FAIL* call. If the MDL is higher than the performance standard, the system cannot be given a *PASS* – an *INCONCLUSIVE* is the best the owner can get.

Fortunately, most vendors provide a “plain English” translation to help explain this level of detail.

“Can SIR be used as a monthly test of piping, too?”

Yes – SIR can meet the monthly release detection requirements for some piping systems. SIR is, in effect, a test of the entire UST system. Losses from the tank and from the piping up to the dispensing meter are reported regardless of their origins. So whether losing product as a result of a tank leak, a line leak, miscalibrated equipment or theft, a *FAIL* will result if the estimated leak rate exceeds the threshold leak rate.

However, petroleum product UST piping systems installed or replaced after Nov. 10, 2007, and all hazardous substance UST piping systems are required to perform interstitial monitoring at least once every 30 days. For those piping systems, SIR may be performed in addition to interstitial monitoring.

Additionally, SIR methods may not work for piping systems that dispense through a master and satellite dispenser system, as is typical at truck stops. In order to satisfy the monthly release detection requirement for the entire underground piping run, the master and satellite dispenser units must each be equipped with a meter. If only the master dispenser is equipped with a meter, SIR methods will not see any leakage from the piping that connects the master and satellite dispensers.

And remember – in addition to the requirement for monthly release detection – pressurized piping systems are required to be equipped with an automatic Line Leak Detector that continuously monitors the piping for large leaks. SIR cannot satisfy this requirement.

For additional information on the release detection requirements and available options for piping, see Storage Tank Program fact sheet 2630-FS-DEP1507 “How to Detect Releases in Underground Piping Systems,” available on the DEP website (www.dep.pa.gov, Businesses > Land > Storage Tanks).

“How much does SIR cost?”

Unlike most other methods, SIR has no installation costs, and equipment costs are minimal—a well-calibrated dispensing meter and a good gauge stick are about all that is needed. While vendor costs will vary, monthly monitoring for a single facility with three USTs costs about \$350 to \$1000 per year.

“There are so many vendors. How to choose?”

Whether the owner has decided to invest in SIR services or other release detection methods, the basic steps are similar:

- Request information from the potential vendors. Compare their services, option packages and prices to see which vendor best meets your needs. Ask for references and check them.
- Contact the appropriate DEP regional office to determine if the vendor has provided the National Work Group on Leak Detection Evaluations (www.nwglde.org/) with adequate data to ensure that the procedure meets the minimum DEP requirements.
- Contact the Better Business Bureau or the state consumer protection office in the area where the vendor’s headquarters is located to see if there have been any complaints lodged against the vendor.

Pennsylvania Department of Environmental Protection Storage Tank Offices

Central Office
Bureau of Environmental Cleanup
and Brownfields
Division of Storage Tanks
PO Box 8763
Harrisburg, PA 17105-8762
1-800-42-TANKS (in Pennsylvania)
717-772-5599 (local and out of state)

Southeast Region
2 East Main St.
Norristown, PA 19401-4915
484-250-5960
Counties: Bucks, Chester, Delaware,
Montgomery and Philadelphia

Northeast Region
2 Public Sq.
Wilkes-Barre, PA 18701-1915
570-826-2511
Counties: Carbon, Lackawanna, Lehigh,
Luzerne, Monroe, Northampton, Pike,
Schuylkill, Susquehanna, Wayne and Wyoming

Northcentral Region
208 West Third St., Suite 101
Williamsport, PA 17701
570-327-0500
Counties: Bradford, Cameron, Centre,
Clearfield, Clinton, Columbia, Lycoming,
Montour, Northumberland, Potter, Snyder,
Sullivan, Tioga and Union

Southcentral Region
909 Elmerton Ave.
Harrisburg, PA 17110
717-705-4705
Counties: Adams, Bedford, Berks, Blair,
Cumberland, Dauphin, Franklin, Fulton,
Huntingdon, Juniata, Lancaster, Lebanon,
Mifflin, Perry and York

Southwest Region
400 Waterfront Dr.
Pittsburgh, PA 15222
412-442-4091
Counties: Allegheny, Beaver,
Elk, Cambria, Fayette, Greene,
Somerset, Washington and Westmoreland

Northwest Region
230 Chestnut St.
Meadville, PA 16335-3481
814-332-6648
Counties: Armstrong, Butler, Clarion, Crawford,
Erie, Forest, Indiana, Jefferson, Lawrence,
McKean, Mercer, Venango and Warren

For more information, please visit www.dep.pa.gov, Businesses > Land > Storage Tanks.