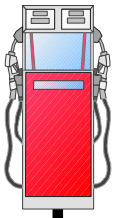

National Work Group on Leak Detection Evaluations Document

Alternative Test Procedures for Evaluating Leak Detection Methods: Protocol for Determining Applicability of SIR Methods for Manifolded Tanks and Determining Size Limitations

November 14, 1996

This document outlines the NWGLDE position on SIR methods applicability to manifolded tank systems and for determining size limitations.

PREPARED FOR:

The KWA CD-ROM

(Version 1.0)

KWA

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STATE OF TENNESSEE
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To: SIR Vendors, SIR Evaluators

From: Lamar Bradley, National Work Group on Leak Detection Evaluations

Date: January 10, 1997

Subject: Clarification of Memo dated 11/14/96 regarding Protocol for Determining Applicability of SIR Methods for Manifolded Tanks and Determining Size Limitations

It was brought to my attention that perhaps I was not clear in my memo dated 11/14/96. This memo is an effort to clarify any confusion inadvertently created by that memo. I will not reiterate everything in the 11/14/96 memo, but a few things bear repeating. The Environmental Protection Agency's Standard Test Procedure for Evaluating Leak Detection Methods: Statistical Inventory Reconciliation Methods (June 1990) provides no guidance on evaluating SIR performance on manifolded systems. The NWGLDE formed an ad hoc committee to develop a modified protocol establishing guidelines for evaluating SIR performance on manifold tank systems. To our knowledge, this is the only SIR protocol that addresses: 1. Applicability of SIR for manifold tank systems as well as single tank systems, 2. Determination of tank size limitations for both single tanks and manifold tank systems, and 3. Limitation for the number of tanks in a manifold. This is the only document that standardizes evaluations industry-wide for applicability of SIR for manifold tanks.

If a SIR method has **already** undergone an evaluation with manifold tank data, it may not be necessary for additional analysis of data sets by a vendor. It will require additional analysis of test results by an evaluator to determine if a SIR method performs adequately on both single and manifolded tank systems. This protocol is also requires analysis to determine if a method performs better on smaller tanks. It also explains how to calculate maximum tank size limits for single and manifolded tank systems, as well as applying limits for number of tanks in a manifold.

The Work Group voted to allow only systems that had been evaluated following this protocol appear on the list as having been evaluated for manifolded systems using an approved protocol. What this means is that although no one is **required** to submit to the manifold analysis, the NWGLDE List will distinguish between those SIR methods that **have** been evaluated according to the protocol and those that **have not**.

There will be two distinct differences in the listings:

First, for those methods **evaluated with manifold tank data and results analyzed according to the 9/27/96 protocol,** size limits will be listed for single tanks and/or manifold systems and the number of tanks determined by the third party evaluator.

Methods **evaluated with manifold tank data which have not had results analyzed according to the 9/27/96 protocol,** will not have sizes listed, but the following statement will appear: **Capacity:** "Size limits using an approved protocol for manifold tank systems have not been determined."

Second, for those methods **evaluated with manifold tank data and results analyzed according to the 9/27/96 protocol,** the following statement will appear in the **Comments** section: "This method **has** been evaluated for manifold tank systems using an approved protocol."

Methods **evaluated with manifold data which have not had results analyzed according to the 9/27/96 protocol,** the following statement will appear in the **Comments** section: "This method **has not** been evaluated for manifold tank systems using an approved protocol."

For SIR methods that **were not evaluated with manifold tank data**, the statement in the **Comments** section "This evaluation did not include data from manifold tanks" will remain.

There are a number of evaluations that are pending review by the work group. If yours is one of those it would be very helpful if you would contact me by phone (615) 532-0952, fax (615) 532-0938, or email lbradley2@mail.state.tn.us and let me know if you plan to pursue analysis of your method using the 9/27 protocol. If you have no plan to do that, the SIR subcommittee can resume its review of your method without further delay.

Enclosed you will find a status report of SIR methods sorted by whether the method is currently listed in the NWGLDE List. If you notice any errors, please let me know.

cc: The National Work Group on Leak Detection Evaluations

STATE OF TENNESSEE
DEPARTMENT OF ENVIRONMENT AND CONSERVATION

To: SIR Vendors, SIR Evaluators, Other Interested Parties

From: SIR Subcommittee, National Work Group on Leak Detection Evaluations

Date: November 14, 1996

Subject: Protocol for Determining Applicability of SIR Methods for Manifolded Tanks and Determining Size Limitations

Manifolded tank systems are a significant portion of the tank population. Many SIR vendors feel their systems are capable of detecting leaks from manifolded systems. The SIR Subcommittee of the National Work Group on Leak Detection Evaluations found that some SIR systems had been evaluated using data from manifolded systems. Others had not, but were using SIR methods on manifolded systems. The Environmental Protection Agency's Standard Test Procedure for Evaluating Leak Detection Methods: Statistical Inventory Reconciliation Methods (June 1990) provides no guidance on evaluating SIR performance on manifolded systems. As a result, the NWGLDE formed an ad hoc committee to develop a modified protocol establishing some guidelines for evaluating SIR performance on manifold tank systems. Members of this committee were Lamar Bradley, Beth DeHaas, Bill Faggart, Jerry Flora, Mike Kadri, Arron Rambach, and Ken Wilcox.

The enclosed protocol is the result of their work. It may not require any further analysis of data sets by a vendor. It will require additional analysis of test results by an evaluator to determine if a SIR method performs adequately on both single and manifolded tank systems. This protocol is also requires analysis of test results to determine if a method performs better on smaller tanks. It also explains how to calculate maximum tank size limits for single and manifolded tank systems.

This protocol was reviewed and approved by the NWGLDE on September 27,1996. The Work Group also voted to allow only systems that had been evaluated following this protocol to be listed as having been evaluated for manifolded systems using an approved protocol.

Presently there are two SIR methods on the List with both single and manifolded tank size limits. This was done prior to development of this protocol. Vendors of these methods should have the calculations required in this protocol completed and results submitted if they wish to remain listed for both single and manifolded tanks.

Please be aware that this is not an "EPA approved" protocol, but is a protocol addendum approved by the NWGLDE. EPA is working on an update of the present SIR protocol. It is not known how soon this updated protocol will be available. Many vendors have had SIR methods evaluated using data from manifolded systems. The SIR Subcommittee believes that these vendors should be able to have their systems included on the List. This protocol is an effort to ensure that these SIR methods can perform adequately on both single and manifold tank systems.

If you have questions about using this protocol or inclusion of your method on the Work Group List, please call Lamar Bradley at 615 532-0945

cc: The National Work Group on Leak Detection Evaluations

PROTOCOL FOR DETERMINING APPLICABILITY OF A SIR METHOD FOR MANIFOLDED TANKS AND DETERMINING SIZE LIMITATION

November 14, 1996

If a SIR vendor desires to use a SIR method on single tanks as well as manifolded tank systems, a number of things must first be determined. SIR vendors should discuss their desire for their method's use with the third party evaluator so that the selected data sets submitted by the evaluator for analysis by the vendor will meet the criteria established in this protocol and the target goals of the vendor. Criteria for evaluation of SIR methods for single tanks are described in "Standard Test Procedures for Evaluating Leak Detection Methods: Statistical Inventory Reconciliation Methods" June, 1990, also known as the "SIR Protocol". Much of the statistical approach in this document relied upon and was adapted from “Evaluation Protocol for Continuous In-Tank Leak Detection Systems” by Midwest Research Institute, dated April 7, 1995. Evaluators wishing to evaluate SIR methods for applicability to manifolded systems (tanks connected by a free flowing siphon) must modify SIR evaluations using the following restrictions and procedures. (Any inadvertent conflicts created by these procedures must be resolved in favor of these procedures in order for the evaluation to apply to manifolded tank systems.)

1. INTRODUCTORY REQUIREMENTS

A. If a SIR method is to be used for manifolded tanks as well as single tanks, the evaluation must contain between 30% and 75% conclusive data from manifolded tank systems. This is a minimum of 12 conclusive data sets for quantitative methods and 36 conclusive for qualitative methods.

B. If manifold tank systems are included, then the SIR program is limited to the number of tanks in the 80th percentile plus one. The tank records are to be ordered by the number of tanks in the manifold from least to largest starting with the single tank records. The 80th percentile is the tank record such that 80% of the tank records have less than or equal to this number of tanks in the record. For example, a data set with 41 conclusive records has 28 single tank records, 4 two tank records, and 9 three tank records. Take 80% of 41 to get 32.8. Fractions are moved to the next integer, in this case 3. Counting from smallest to largest, the 33rd record has 3 tanks in the manifold. Therefore, limit the method to manifolded UST systems that have no more than four tanks.

C. Again, the distribution of the number of tanks in the manifold should represent the intended use of the method. However, use of the method should not be extended to more difficult cases without justification based upon adequate data in the evaluation.

D. To justify the use of the SIR method for single and manifold tanks, results for single and manifold tanks must be shown to be similar. To make this comparison, the database must conform to the following:

I. At least 24 of the 41 records must be usable and conclusive for quantitative methods; 80 of the 120 conclusive and usable for qualitative methods.

II. For **quantitative** methods, a minimum of 3 of the 8 records from tight tank conditions, and 3 of the 8 records from each group with induced leak rates must be from manifolded systems. The total number of manifolded record results which are conclusive and usable must be at least 12.

III. For **qualitative** methods, a minimum of 18 of the 60 records from tight tank conditions, and 18 of the 60 records with induced leak rates must be from manifolded systems. The total number of manifolded record results which are conclusive and usable must be at least 36.

If the database conforms to these requirements, divide the data records into two groups based on whether the tanks are single or manifold. If the database does not conform to these requirements, then the evaluation may not be certified for both single and manifold tanks.

2. QUANTITATIVE SIR METHODS-MANIFOLDING

Calculate the overall P(D) and P(FA) for the entire database used in the evaluation using the equations in the original EPA SIR protocol to determine whether the combined data meets the 95% and 5% performance standard. If the combined data does not meet the performance standard, then the SIR method may not be used on manifolded or single tanks. If the combined data does meet the 95% and 5% performance standard, then calculate the mean and standard deviation separately for the single and manifold groups. Also, test for zero bias for each group. This can be done by using the following formulae<u>on each group separately</u>.

2A. Mean Squared Error for Single and Manifolded Tanks Separately

The mean squared error, MSE, is given by

$$MSE = \sum_{i=l}^{n} (L_i - S_i)^2/n$$

where L_i is the estimated leak rate reported by the SIR method and S_i is the actual induced leak rate, for i from l to n for the different data bases. The bias, B, is estimated by

$$B = \sum_{i=l}^{n} (L_i - S_i)/n$$

The bias, B, is the average difference between the measured and induced leak rates over the number of tests. The bias is a measure of the accuracy of the SIR method and can be either positive or negative.

2B. Variance and Standard Deviation for Single and Manifolded Tanks Separately

The variance is found from the formula

$$\sigma^2 = \sum_{i=1}^{n} [(L_i - S_i) - B]^2/(n-l)$$

Denote the standard deviation by SD. The standard deviation is the square root of the variance.

2C. Test for Zero Bias for Single and Manifolded Tanks Separately

To test whether the SIR method has a bias that is statistically significantly different from zero, the following statistical test on the bias, B, calculated above is performed. Compute the t statistic

$$t_b = \sqrt{n}\bar{B}/SD$$

From a t-table, obtain the critical value, corresponding to a t with (n-l) degrees of freedom and a two-sided 5% significance level (a=.05). For example, with n = 28, there are 27 degrees of freedom and the two-sided 5% significance level (a=.05) leads to a critical value of 2.052. Denote this value by t_c. Compare the absolute value of t_b to t_c. If the absolute value of the calculated t_b is less than the critical value, the bias is not significantly different from zero and the method is assumed unbiased. If the absolute value of the calculated value of t_b exceeds the critical value, then the method has a significant bias. If the bias, B, is positive, the method systematically overestimates the leak rate. If B is negative, the method systematically underestimates the leak rate.

2D. Comparison of Standard Deviations of Single vs. Manifolded Tanks

Use a two-sample F-test to test whether the variances of the two groups are equal. Calculate

$$F = (SD_1/SD_2)^2$$

where SD_1 and SD_2 are the standard deviations calculated from the two groups. In forming the F ratio, use the standard deviation with the larger calculated value in the numerator. Compare the calculated value of F to the 95th percentile of an F-distribution with (n_1 - 1) degrees of freedom in the numerator (corresponding to SD_1) and (n_2 - 1) degrees of freedom in the denominator (corresponding to SD_2). The sample sizes are n_1 and n_2, respectively. If the calculated value of F **is less than** the tabled value, there is **no significant evidence that the two population variances are different. In this case, there is justification for using the method on both single and manifolded tanks.**

2E. Comparison of Biases of Single vs. Manifolded Tanks

If the standard deviations of the single and manifolded groups are not significantly different, test to see if the biases are different for the two groups of tanks. Use a two-sample t-test to test whether there is any significant difference in the biases of the two groups. Calculate

$$t_{bp} = (B_1-B_2)/(S_p \sqrt{1/n_1 + 1/n_2})$$

where S_p is the pooled standard deviation of the two groups and is calculated from

$$S_p = \sqrt{[(n_1- 1)SD_1^2 + (n_2 - 1)SD_2^2]/(n_1+ n_2- 2)}$$

Compare t_{bp} to a two-sided 5% critical value from a t-distribution with (n_1+n_2-2) degrees of freedom (a=.05). If the absolute value of t_{bp} **does not exceed** the critical value, then there is no evidence that the bias is different for single tanks compared to manifold tanks.**In this case, use of the method for both types of tanks is justified.**

If the standard deviations and biases of single vs. manifolded tanks **are not significantly different**, then the SIR method is not affected by manifolding. Therefore, it is not necessary to calculate the P(D) and P(FA) separately for each. It is only necessary to report the overall P(D) and P(FA) for the combined data. **There will be only one volume limitation which will be applicable to both single and manifolded USTs.** Volume limitation for quantitative SIR methods is determined in Section 3 (skip Sections 2F and 2G).

However, if either the standard deviations or biases of single vs. manifolded groups **are significantly different** (i.e., the calculated value of F exceeds the tabled value or the absolute value of t_{bp} exceeds the percentile from the t-table), then there is evidence that **the performance of the method is affected by manifolding.** In this case, continue with the computation of the P(D) and P(FA) separately for the single and manifolded tank groups using the following formulae:

2F. Probability of a False Alarm, P(FA), for Single and Manifolded Tanks, Separately

The probability of a false alarm, P(FA), is the probability that the estimated leak rate will exceed the threshold or criterion for indicating a leak when in fact the tank is actually tight. Generally, if the calculated leak rate exceeds a specified leak rate or threshold, C, (for example 0.12 gallon per hour), the tank is judged by the SIR method to be leaking. If C denotes the criterion or threshold for indicating a leak, B denotes the bias of the method, and SD denotes the standard deviation, then the probability of a false alarm can be written as:

$$P(FA) = P\{ t > (C-B)/SD\}$$

where the probability is calculated from a one-sided t-distribution with (n-l) degrees of freedom. For example, if there are 28 single tank records and 13 manifolded tank records, the degrees of freedom would be 27 for the P(FA) for single tanks and 12 for the P(FA) for manifolded tanks. This formula assumes that the errors are approximately normally distributed. If it was determined in Section 2C that the bias is not significantly different from zero, then B is taken to be zero.

2G. Probability of Detecting a Leak Rate of R Gallon Per Hour, P(D), for Single vs. Manifolded Tanks, Separately

The probability of detection, P(D), is the probability that the method will correctly identify a leak of specified size. In general for a leak rate of size R, P(D) is given by:

$$P(D) = P\{t > (C-R-B)/SD\}$$

where C, B, and SD are as before. The probability is calculated from the one-sided t-distribution with (n- 1) degrees of freedom. Note, that if the bias is negligible and the threshold is exactly 50% of the leak rate, then P(D) plus P(FA) will always equal exactly 1.0.

Assume that the method does not perform equivalently on single and manifolded tanks. If both the single and manifolded groups meet the 95% and 5% performance standard, then the method may be used on both single and manifolded tanks systems. However the difference in performance should be reported. In other words, report the P(D) and P(FA) separately for single and manifolded tanks. The evaluator should not report the overall P(D) and P(FA) for the combined data because the method does not work equivalently on single and manifolded tanks.

If only one group meets the 95% and 5% performance **standard, then the use of the method must be limited to the group (single tanks or manifolded tanks) for which the performance standards are met.** Report the P(D)

and P(FA) for the group that meets the criteria. The evaluator should not report the overall P(D) and P(FA) for the combined data because the method is limited to one group of tanks.

3. QUANTITATIVE SIR METHODS-VOLUME LIMITATION

The distribution of tank sizes in the database should be as nearly uniform as practical. The database should not emphasize small tanks. Test data should represent the population of tanks for which the method is intended to be used. The results of an evaluation can be extended to tanks 50% larger than the 80th percentile of the tank sizes used in the evaluation data set if the method is found not to be affected by increasing volume.

Determination of whether tank size affects the performance of the SIR method can be conducted on the entire database as a whole if the method is found to perform equivalently on single and manifolded tanks. In this case, there will be only one maximum volume limitation that is applicable to both single tanks and manifolded systems.

However, if the procedures in Section 2 above reveal that the method does not perform equivalently on single and manifolded tanks, then the affect that volume has on the performance of the SIR method must be determined separately for single and manifolded tanks. In this case, there will be two maximum volume limitations--one that is applicable to single tanks and the other for manifolded systems. In addition, if the procedures in Section 2 above reveal that the method meets the 95% and 5% performance standard for only one group of tanks (for example, single tanks) then the procedures for determining the effect of volume on performance is limited to single tanks.

The tank records are to be ordered by volume from least to greatest, and the various percentiles determined. The volume of a manifolded tank record is the total volume of the tanks in the manifold. The smallest, 25th, 50th (median), 75th, 80th percentile, and the largest tank size are reported on the results form. To find a tank size for a given percentile, take the percentile as a percentage of the sample size, and count up from the smallest tank until that number of tank records is reached. For example, for the 25th percentile, with n=41 records, take 25% of 41 to get 10.25. Fractions are moved up to the next integer, 11 in this case. The 25th percentile is the 11th tank size in the set of ordered tank sizes, counting from smallest to largest. If the result of taking a percent of the sample size is not an integer, use the next larger integer.

In particular, the 80th percentile determines a limitation on tank size. If there are 41 conclusive records, the 80th percentile is the 33rd tank size counting from the smallest to the largest. If a different number of records is used, the 80th percentile is the tank size corresponding to the integer greater than or equal to 0.8n, where n is the number of records, again counting from the smallest tank size to the largest.

If the method is not found to be adversely affected by increasing tank volume, then the maximum tank size limitation is 1.5 times the 80th percentile of tank sizes used in the evaluation. If the method **is** found to be adversely affected by increasing tank volume, then the maximum tank size limitation is reduced to the smaller of the largest tank in the evaluation, or 1.25 times the 80th percentile.

To justify extrapolation to larger tank sizes, the results for small and large tanks must be shown to be similar. To make this comparison, divide the data records into two groups based on volume. The two groups should be of nearly equal size, but if there are many records at one tank size (e.g., 10,000 gallons), it may not be possible to make the two groups exactly equal.

For example, in a database consisting of 41 conclusive records, suppose 28 are single tank records and 13 are manifold tank systems. Suppose it was determined in Section 2 that the method does not perform equivalently on single and manifolded tanks, but it does meet the 95% and 5% performance standard for both types of tanks. Therefore, the effect that increasing volume has on the performance of the method must be determined separately for single and manifolded tanks. Divide the 28 single tanks into two groups based on volume (small and large) as close to

the median as possible. Also, divide the 13 manifolded records into two groups based on volume as close as possible to the median. The volume of a manifolded tank record is the total volume of the tanks in the manifold.

3A. Variance and Standard Deviation for Large and Small Tanks Separately

Calculate the means, biases, and standard deviations separately for the large and small volume groups. This can be done by using the formulae in Section 2A and 2B separately on the two volume groups. (It is not necessary to test for zero bias for the two volume groups because there is no need to determine the P(FA) and P(D) for each volume group.) Use a two-sample F-test to test whether the variances of the large and small groups are equal. Calculate

$$F = (SD_1/SD_2)^2$$

where SD_1 and SD_2 are the standard deviations calculated from the two volume groups. In forming the F ratio, use the standard deviation with the larger calculated value in the numerator. Compare the calculated value of F to the 95th percentile of an F-distribution with (n_1 - 1) degrees of freedom in the numerator (corresponding to SD_1) and (n_2 - 1) degrees of freedom in the denominator (corresponding to SD_2). The sample sizes are n_1 and n_2, respectively. If the calculated value of F is less than the tabled value, **there is no significant evidence that the two population variances are different.** In this case, there is justification that the method is not affected by increasing volume.

3B. Comparison of Biases of Large vs. Small Tanks

If the standard deviations of the large and small volume groups are not significantly different, test to see if the biases are different for the two volume groups. Use a two-sample t-test to test whether there is any significant difference in the biases. Calculate

$$t_{bp} = (B_1-B_2)/(S_p \sqrt{1/n_1 + 1/n_2})$$

where S_p is the pooled standard deviation of the two volume groups and is calculated from

$$S_p = \sqrt{[(n_1- 1)SD_1^2 + (n_2-1)SD_2^2]/(n_1+n_2-2)}$$

Compare t_{bp} to a two-sided 5% critical value from a t-distribution with (n_1+n_2-2) degrees of freedom (a=.05). If the absolute value of t_{bp} **does not exceed** the critical value, then there is no evidence that the bias is different for small tanks compared to large tanks. **In this case, there is justification that the method is not affected by increasing volume.**

If the standard deviations and biases of large vs. small volume groups are not significantly different, then the SIR method is not affected by increasing volume. In this case, extrapolation to 1.5 times the 80th percentile of tank sizes is justified (skip Section 3C).

3C. Determination of Whether Method Is Adversely Affected by Increasing Volume

If either the standard deviations or biases of large vs. small volume tanks are significantly different (i.e., the calculated value of F exceeds the tabled value or the absolute value of tbp exceeds the percentile from the t-table), then there is evidence that the **performance of the method is affected by volume.** In this case, it must be determined whether the method is adversely affected by increasing volume. Compare the standard deviations calculated in Section 3A for the large and small volume groups.

If the standard deviation of the small volume group is greater than the standard deviation of the large volume group, then the method is not adversely affected by increasing volume. In this case, the maximum size limitation is 1.5 times the 80th percentile. On the other hand, if the standard deviation of the large volume group is greater than the standard deviation of the small volume group, then the method is adversely affected by increasing volume. In this case, the maximum tank size limitation is reduced to the smaller of the largest tank in the evaluation or 1.25 times the 80th percentile.

4. QUALITATIVE SIR METHODS-MANIFOLDING

Calculate the overall P(D) and P(FA) for the entire database used in the evaluation using the equations in the original EPA SIR protocol to determine whether the combined data meets the 95% and 5% performance standard. It is not necessary to report this overall P(D) and P(FA) for qualitative methods. If the combined data **does not** meet the performance standard, then the SIR method may not be used on manifolded or single tanks. If the combined data does meet the 95 % and 5 % performance standard, then divide the entire database into two groups-one group consisting of single tanks and the other group consisting of manifolded records. There must be at least 18 tight records and 18 records with simulated leaks for both the single tank group and the manifolded tanks group, however the total number of manifolded records must be at least 36.

Compute the P(D) and P(FA) separately for the single and manifolded group in accordance with the following.

Actual Status	Reported			
	Tight	Leaking	Invalid or Inconclusive	Total
Tight	T_1	L_1	X_1	N_1
Leaking	T_2	L_2	X_2	N_2

It is possible that the SIR method may not be able to produce a valid result (i.e., pass or fail). That is the SIR method determines that data or operational problems have occurred so that no valid test result can be determined. These are invalid or inconclusive results and should be reported in the table above. In the past some evaluators have chosen not to report inconclusives and invalids in the evaluation. They must be reported regardless of the reason for the inconclusive or invalid.

The numbers in the table are used to directly estimate the P(D) and P(FA). Since the P(D) and P(FA) must be calculated separately for single and manifolded tanks, it will be necessary to complete the above table twice: once for single tanks, and once for manifolded tanks. The number of tight tanks incorrectly identified as leaking, divided by the total number of tight tanks estimates the P(FA). That is

$$P(FA) = L_1 /(N_1 - X_1)$$

where the letters in the cells of the table denote the number of results in the category indicated by the cell label. In determining the ratio in the equation for P(FA), the denominator should be reduced by the number of invalid or inconclusive results.

Similarly, the P(D) is estimated by the number of leaking tank records correctly identified as leaking divided by the number of leaking tanks or,

$$P(D) = L_2 /(N_2 - X_{2)}$$

In determining the ratio in the equation for P(D), the denominator should be reduced by the number of invalid or inconclusive results.

In the table **for single tanks** and **the table for manifolded tanks**, N_1 is the number of tank records from tight tanks and N_2 is the number of tank records with induced leaks. Since the evaluation must have between 30% and 75% conclusive data from manifolded tanks, $T_1 + T_2 + L_1 + L_2$ must be at least 36 for both the single and manifolded tables. Also, T_1 plus L_1 must be at least 18 for the manifolded table. Likewise, T_2 plus L_2 must be at least 18 for the manifolded table. In addition, T_1 plus L_1 from the single table added to T_1 plus L_1 from the manifolded table must be at least 60. Likewise, T_2 plus L_2 from the single table added to T_2 plus L_2 from the manifolded table must be at least 60.

The proportion of records declared invalid must also be reported separately for the tight and leaking records as well as for all records. These proportions are calculated as

$$PI\ (Tight) = X_1/N_1$$
$$PI\ (Leak) = X_2/N_2$$
$$PI\ (All) = (X_1 + X_2)/(N_1 + N_2)$$

for the proportion of invalid records among tight, leaking, and all records, respectively. The proportion of invalid records among all tank records provides an estimate of the proportion of tanks in a population represented by the evaluation data base for which this method cannot be used.

In order for the method to meet the EPA performance standard, P(FA) must be less than or equal to 0.05 (5%) and P(D) must be at least 0.95 (95%). Suppose 25% out of 120 tank records were manifolded systems and half of these had induced leaks. The number of manifolded records with induced leaks would be 15 and the SIR method could make zero missed detections out of the 15 records and still meet these requirements. It is possible that the method might not make any errors, giving an estimated P(FA) of 0 or an estimated P(D) of 1. Since no method is expected to have zero errors in practice, it is important to calculate a confidence interval for the discrete proportion of false alarms or detections to give an indication of what range should be expected for the P(FA) or P(D) in practice.

If no false alarms occur in the evaluation data base, the upper confidence limit for P(FA) is found from

$$UL = 1 - a^{1/(N_1 - X_1)}$$

where $(1 - a)$ is the confidence coefficient, which is generally set at 0.95. The number N_1 should not be reduced by the number of invalid or inconclusive test results among the tight tank records. For one or more false alarms, the confidence limits are calculated from confidence limits for the parameter of a binomial distribution. (See page 23 of the original EPA SIR evaluation protocol.)

If no missed detections occur in the evaluation in detecting leaks, a lower confidence bound for P(D) can be calculated from

$$LL = a^{1/(N_2 - X_2)}$$

where again $(1-a)$ is the confidence coefficient, usually set at 0.95. For one or more missed detections, the confidence limits for the binomial are used. (See Page 24 of the original EPA SIR protocol.)

If both single and manifolded groups meet the 95% and 5% performance standard, then the method may be used on both single and manifolded tanks systems, however the difference in performance should be reported. In other words, report the P(D) and P(FA) separately for single and manifolded tanks. The evaluator should not report the overall P(D) and P(FA) for the combined data because there is no method for determining whether a qualitative SIR method performs equivalently on single and manifolded tanks.

If only one group meets the 95% and 5% performance standard, **then the use of the method must be limited to the group (single tanks or manifolded tanks) for which the performance standards are met.** Report the P(D) and

P(FA) for the group that meets the criteria. The evaluator should not report the overall P(D) and P(FA) for the combined data because the method is limited to one group of tanks.

5. QUALITATIVE SIR METHODS-VOLUME LIMITATION

If it is determined in Section 4 that the method may be used on both single and manifolded tanks, then it is necessary to determine only one maximum volume limitation for the SIR method. This volume limit will be applicable to both single and manifolded tanks. If it is determined in Section 4 that the SIR method is limited to one class of tanks only (say single tanks), then a maximum volume limitation must be determined for single tanks only.

Divide the database into two groups by volume. If the qualitative SIR method may be used on both single and manifolded tanks, then consider all records in the database. If the qualitative SIR method is limited to only one group, then only consider records from that type of group.

Compute the P(D) and P(FA) separately for the large volume group and the small volume group in accordance with procedures in Section 4. You will have to create two more tables.

If both the large and small volume groups meet the 95% and 5% performance standard, extrapolation to 1.5 times the 80th percentile is justified. If one of the groups does not meet the performance standard, then the volume limit should be reduced to the smaller of the largest tank record or 1.25 times the 80th percentile.

6. ADDITIONAL DATA ANALYSIS REQUIREMENTS AND LIMITATIONS

- At least 24 conclusive and usable test results are required for a quantitative method; at least 80 conclusive and usable results are required for a qualitative method. No more than 30% may be invalid, inconclusive or non-usable from any leak rate group.

- If SIR is used on tank systems using multi-product dispensers with blending valves, there must be a separate totalizer reading and product level measurement for each tank in use. The totalizer must measure all product pumped from the tank for each grade of product before it is mixed with another grade from another tank through a blending valve.

- Data from individual tanks in each manifold system must be combined into a single tank record (as if each system were one tank) before being supplied to the vendor in an evaluation.

- Evaluations performed for vendors who are seeking approval for use of the SIR method on manifold systems as well as single tanks should have the following statement completed by the evaluator and included in the *"Limitations on the Results*" section of the SIR evaluation form:

- For quantitative methods, the SIR method ☐may or ☐may not be used for manifolded tank systems. If the method may be used for manifolded tank systems, circle here if there is no significant difference in performance between single and manifolded tank systems. Was there a significant difference in the performance between single and manifolded tanks? YES NO If NO, report the performance and maximum volume for the overall database in the table below. (There will only be one volume limitation which applies to both single and manifolded tanks. It will not be necessary to complete the table for single and manifold tanks separately.) If YES, overall performance need not be reported, but performance and maximum volume must be reported separately for single and manifolded tanks, and the maximum volume for each group may be different.

QUANTITATIVE EVALUATIONS	P(FA)	P(D)	Maximum Volume
Overall database			
Single tanks only			
Manifolded tanks only with up to _____ tanks			

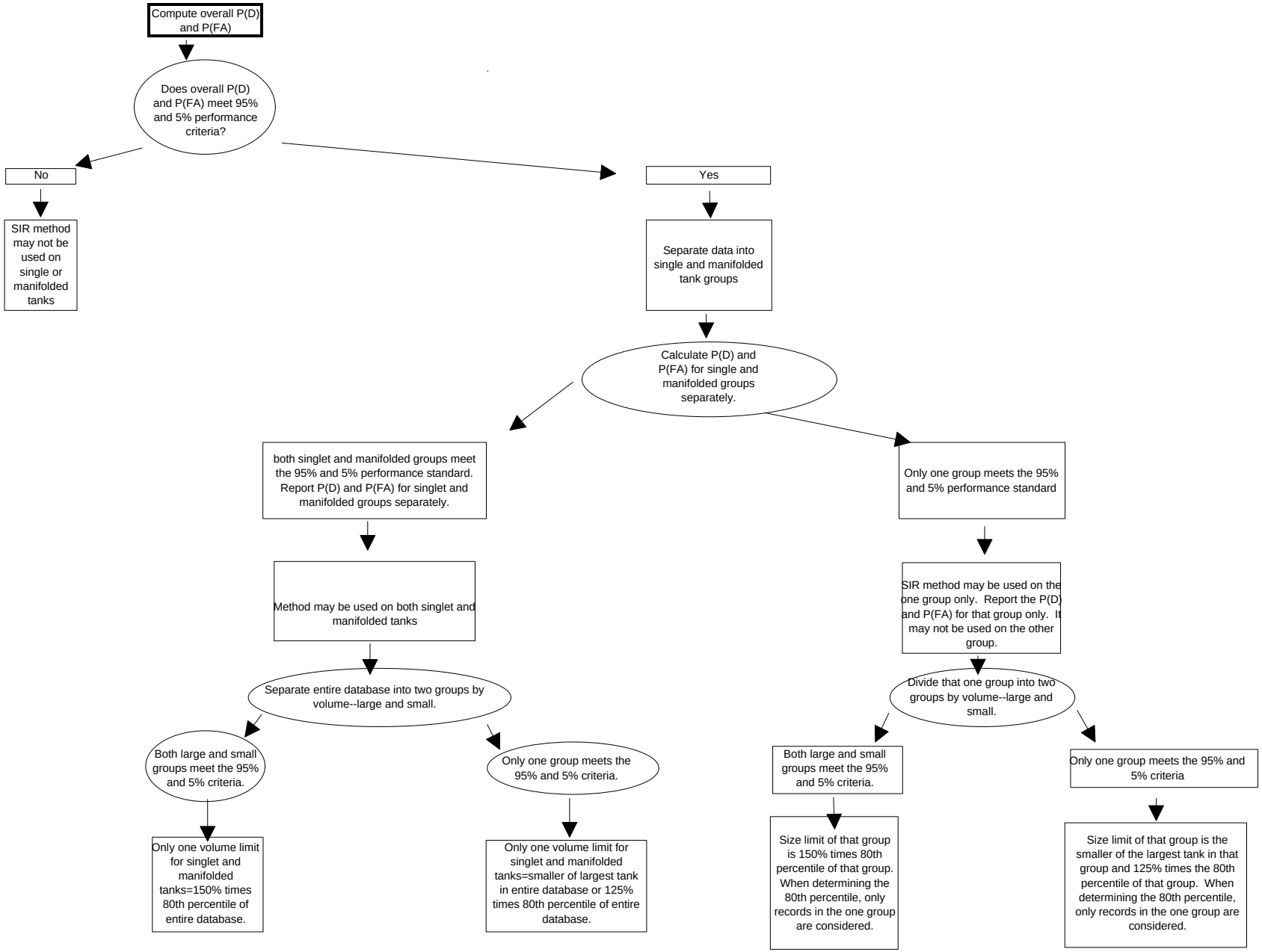
- For quantitative methods, the SIR method ☐ may or ☐ may not be used for manifolded tank systems. Since there is no procedure for determining whether a qualitative method performs equivalently on single and manifold tanks, the overall P(D) and P(FA) for the combined data should not be reported in the following table. If the qualitative method is certified for both single and manifolded tanks, then the maximum volume limitation must be the same.

QUALITATIVE EVALUATIONS	P(FA)	P(D)	Maximum Volume
Overall database	NA	NA	NA
Single tanks only			
Manifolded tanks only with up to _____ tanks			

QUALITATIVE EVALUATIONS	PI (tight)=$X_1/(N_1 - X_1)$	PI(Leak)=$X_2/(N_2 - X_2)$	PI(All)=$(X_1 + X_2)/(N_1+N_2)$
Single tanks			
Manifold systems			
Overall database			

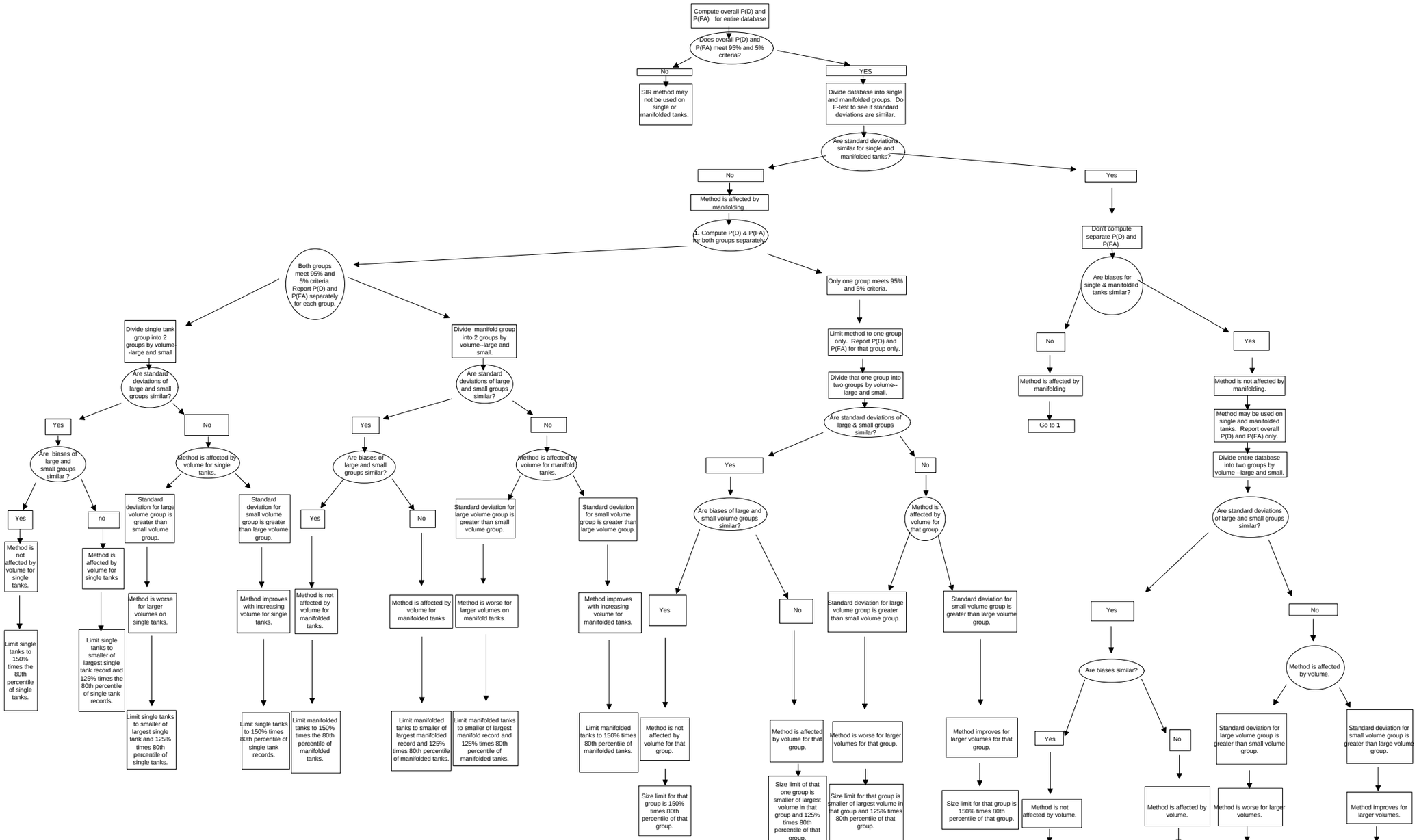
November 14, 1996

DECISION TREE FOR QUALITATIVE SIR EVALUATIONS
Manifolded Tanks



AR, 4-29-96

DECISION TREE FOR QUANTITATIVE SIR EVALUATIONS
Manifolded Tanks



AR, 4-18-96