TCEQ REGULATORY GUIDANCE
Program Support and Environmental Assistance Division
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Air Emissions Leak Detection and Repair (LDAR): Investigation and Enforcement Protocol

Contents

OVERVIEW

This document provides guidance on how to evaluate a Leak Detection and Repair (LDAR) program that has been implemented at a regulated entity site, focusing primarily, but not exclusively, on its ability to identify leaking components.

This document also includes a procedure to test the effectiveness of the LDAR program to detect leaks. This procedure will involve selecting various valves from the population of components, screening them using Method 21, and then determining whether the program is being utilized properly. Compliance will be decided based on number of leakers found.

OBJECTIVE

The primary goal of an LDAR investigation is to determine compliance with recordkeeping requirements, permit conditions, and the monitoring/repairing of components.

To properly implement an LDAR program the regulated entity must:

- Identify components: The regulated entity should have each regulated component assigned a unique identification number (ID), record each ID in a log, and be able to locate each component in the facility and verify its location on the plot plan. The equipment log should be updated when new and replacement pieces of equipment are added or taken out of service.
- Maintain recordkeeping: Proper documentation required by the program must be available at all times. This includes maintaining a list of all ID numbers for all equipment subject to an equipment leak regulation, a detailed site map and equipment specifications, the results of previous performance testing and leak detection monitoring, and dates of process unit shutdowns/startups.
- Monitor components: The regulated entity must properly perform Method 21 leak evaluation using a portable detecting instrument or Audio/Visual/Olfactory (AVO). You may ask personnel to demonstrate use of the instrument to determine competency.
- Repair Components: Components that are found to be leaking must be repaired within the appropriate time frame (As soon as practicable but no later than 15 days after it is detected. The first attempt at repair shall be made no later than 5 calendar days after each leak is detected.).

PREPARATION

Necessary Evaluator Background and Tools

LDAR investigations should be completed within sixty days from the last on-site visit. A maximum of fourteen days should be spent on the on-site portion of the investigation. The company should be notified 2 to 3 days before the on-site visit. This will give the regulated entity time to prepare any documentation you will need to conduct the investigation.

Proper evaluation of a LDAR program requires the investigator to:

- Understand the specific LDAR program requirements for the equipment type under evaluation.

  - For example, if an instrument reading of 10,000 parts per million or greater for agitators, 5,000 parts per million or greater for pumps handling polymerizing monomers, 2,000 parts per million or greater for all other pumps (including pumps in food/medical service), or 500 parts per million or greater for valves, connectors, instrumentation systems, and pressure relief devices is measured, a leak is detected.

- Demonstrate proficiency in performing EPA reference Method 21 screening.
- Demonstrate proficiency in calculating emissions based on program parameters.
- Understand the importance of "simple random sampling" in the selection of components to be screened and the effect of that on the evaluation findings.

The following documents should be readily accessible to the investigator as they provide additional guidance and will be referred to often.

- EPA LDAR Best Practice Guide[1]
- Title 40, Code of Federal Regulations (40 CFR), Section 60, Subpart VV[2]
- 40 CFR 63 Subpart H[3]
- Method 21- Determination of Volatile Organic Compound Leaks[4]
- The New Source Review Documents webpage under Air NSR Permits: Index of Common Permitted Facilities[5]
- Point Source Emissions Inventory Guidelines[6]

Brief Explanation of Sampling, Decision Rule, and Hypothesis Testing

Statistics is used in two ways in this type of LDAR program evaluation: in estimating the leaker rate of the population and in helping decide whether the company's monitoring has been effective in detecting leakers with the program they have put in place.

We will use a decision rule and a hypothesis test to evaluate whether the company has been able to find leakers with their LDAR monitoring program.

To use our decision rule, we will obtain a representative sample from the population of components of interest at the site, determine the number of leakers in that sample, and calculate the leaker rate.

Our decision rule will be whether our sample number of leakers results in a leaker rate that exceeds the company's leaker rate by 2% or more. If our calculated leaker rate is 2% or larger than the company historical value, we will reject the notion that the company leaker rate is correct and conclude that they have failed to properly implement Method 21. Because of the method used to determine how many components to sample, and because we will select components to sample in such a way as to provide each component in the population a

[1] www.epa.gov/sites/production/files/2014-02/documents/ldarguide.pdf
[2] www.ecfr.gov/cgi-bin/text-idx?node=sp40.7.60.vv
[3] www.ecfr.gov/cgi-bin/text-idx?node=sp40.7.60.h
[4] www.epa.gov/sites/production/files/2016-06/documents/m-21.pdf
[5] www.tceq.texas.gov/permitting/air/guidance/newsourcereview/nsr_fac_index.html
[6] www.tceq.texas.gov/airquality/point-source-ei/rg-360-21

relatively equal chance of being sampled, we will be able to state what our Type I statistical error rate is for our hypothesis test when we employ our decision rule. Type I error, part of any statistical hypothesis test, is the chance of concluding that the company leaker rate is wrong when it is correct.

If we apply our sampling results to our decision rule and find that we have sampling evidence sufficient to reject the company claim that their leaker rate is true in favor of our alternative hypothesis that the true leaker rate is at least 2% larger than the company claimed rate, we will be able to state the power of our test to detect the difference. The sampling plan that will be created will enable us to constrain the Type II error associated with our claim. A Type II error is made when the sample-based leaker rate is really right, but we fail to reject the company determined value. We control the Type I and Type II error rates by sampling enough components and doing so in a way that avoids introducing bias into our results. In our evaluation we will sample sufficient components to control Type I error rate to no more than 5% (alpha (α) #.05) and our Type II error rate to no more than 20%(beta(β) #.20) resulting in a power of 80%.

If we sample and determine that we should reject the company claimed leaker rate, then we will use our calculated leaker rate to be the best reflection of actual leaker rate of the population sampled. We will calculate the difference in emissions (tons per year) based on the company vs our leaker rate. This emissions estimate will be used to evaluate the appropriate enforcement response to the uncontrolled emissions found when our decision rule is used to reject the company leaker rate.

Considerations on Assuring a Fair Comparison and Estimating Emissions

We use a statistical sampling technique because we wish to be able to reliably draw conclusions about the leaker rate of the population without monitoring (screening) each component in the population. We are interested in population leaker rate because it is used directly to calculate emissions from the population for regulatory LDAR programs, emissions inventory, and State Implementation Plan (SIP) purposes. Calculating emissions from fugitive emissions sources is fully described in the EPA and NSR guidance documents referred to in the ‘tools’ section above. In short, emissions from a population of components are calculated on a component type/ type of service basis (e.g., valves in light liquid, valves in gas service, etc.), summing the individual contributions of each component/service to arrive at a population tons per year of emissions.

It is critically important that we clearly define the population of components of interest and that we sample the correct number of components from that population. If we do so, we can use the information to test the company claimed leaker rate, and further, we can use the leaker rate in calculating emissions. If we have drawn a sample in a valid way from a population and our decision rule indicates that we must reject the company claim, then we can conclude that Method 21 was not properly implemented. The next step is to decide the impact of the program failure on controlling emissions. Estimating emissions involves multiplying the number of components of a given type in each service by the factors for that component type for that service.

If our population of interest is valves and connectors in light liquid service, then we must use in our testing the total count of valves and connectors in light liquid service and their historical leaker rate. Based on that information, we can select a sample size and sample enough valves and connectors to apply our decision rule. If, based on applying our decision rule against our sampling results, we reject the claimed leaker rate provided by the company, then we can say that the company was wrong about the leaker rate when valves and connectors were the population of interest. Further, our sample results will enable us to state what the leaker rate is from that population as a whole. If we want to estimate the emissions from the population, we need more detail. We can't simply assume that the overall leaker rate is correct for both valves and connectors. We must calculate the leaker rate for valves and connectors separately to calculate emissions correctly.

For example, if a company had 1000 components in a population of interest comprised of 250 valves and 750 connectors and claimed a leaker rate of 1% (10 of 1000 components), we could test that claim by selecting at random 254 components and sampling them. If we found at least 6 leakers in our random sample of components we could reject the company claim of 1% leakers and state that the true leaker rate is 3% or more. We would have evidence that the company had failed to implement Method 21 correctly. In fact, based on our 254-component sample, if we found 13 leakers, we could say the leaker rate of the population as a whole was 5.1%, and further, that a 95% confidence interval about that mean would be 5.1% ± 2.3%. We would not, however, estimate emissions by assuming 5.1% of the valves and 5.1% of the connectors were leaking. If our sample was comprised of 84 valves, 3 of which were found to be leaking (3.6% leakers) and 170 connectors, 10 of which were found leaking (5.88%), then we would use our sample percentages by component type to estimate emissions from the population.

In summary, while we can use our decision rule to establish whether the company has properly implemented Method 21 for the entire population of interest, we can only estimate leaker rates and associated emissions for the population we have sampled. If our evaluation assesses only valves in gas service, then we cannot use the sampling derived leaker rate to estimate the leaker rate of connectors.

SAMPLE SIZE, CRITICAL NUMBER DETERMINATION, AND SAMPLING PLAN

Obtaining a representative sample from a population of interest is critical to the proper evaluation of a LDAR program. This section addresses the methods used to determine sample size, critical number of leaking components, and development of an appropriate sampling plan.

Determining Minimum Number of Components to Sample

From the company provided LDAR records or reports, determine the average number of components in the population and the population average leaker rate for the last 4 to 6 monitoring periods or enough to cover at least the most recent full year of monitoring results.

To determine the minimum number of components to sample, locate the claimed leaker rate within the range of values in the column headings of Table 1. Locate the total component population in the row headings on the left margin of the same table. The value in the intersection of the column and row is the necessary minimum sample size.

Table 1: Minimum Number of Components to Sample Based on Component Population Count and Company Determined Leaker Rate

Note: (Values based on a hypergeometric distribution alpha=0.05, beta=0.20, Null Hypothesis=company claim leaker rate is correct, Alternate Hypothesis= the actual leaker rate is greater than or equal to company claimed leaker rate plus 2%)

Total Population Component Count	Company Claimed Leaker Rule (# Leaking components/ # components in the population)										
	Up to 0.005	0.006 up to 0.010	0.011 up to 0.015	0.016 up to 0.020	0.021 up to 0.025	0.026 up to 0.030	0.031 up to 0.035	0.036 up to 0.040	0.041 up to 0.045	0.046 up to 0.050	0.051 up to 0.055
100 to 150	87	101	110	110	116	120	124	124	127	129	131
151 to 300	139	159	165	173	193	200	213	218	226	233	236
301 to 400	152	167	183	204	228	265	278	284	290	296	305
401 to 500	155	172	201	234	250	278	280	295	300	312	328
501 to 600	158	207	220	263	281	295	343	349	354	359	362
601 to 700	159	211	238	266	303	319	343	353	370	391	402
701 to 800	161	223	253	268	310	362	386	389	392	408	422
801 to 900	162	234	272	297	331	385	385	392	422	439	462
901 to 1,000	163	245	278	298	337	387	391	411	443	456	481
1,001 to 1,500	165	254	280	330	386	414	451	486	526	551	567
1,500 to 2,000	167	256	316	359	392	460	495	525	565	599	629
2,001 to 2,500	214	258	316	361	416	462	515	562	598	613	671
2,5001 to 3,000	216	258	316	390	443	485	557	581	634	660	703
3,001 to 6,000	218	260	320	393	471	532	600	639	704	742	806
6,001 to 10,000	219	261	354	422	472	555	622	676	738	790	850
10,001 to 25,000	219	262	355	423	498	557	643	696	773	823	894
25,001 to 100,000	220	262	356	424	499	579	644	715	790	854	924
100,001 to 250,000	220	301	356	424	499	579	644	715	791	855	924

Determining the Critical Number of Leakers

To determine the critical number of leakers, locate the claimed leaker rate within the range of values in the column headings of Table 2. Locate the total component population in the row headings on the left margin of the same table. The value in the intersection of the column and row is the critical number of leakers.

Table 2: Critical Number of Leakers based on Sample Size from Table 1

Note: (Values based on a hypergeometric distribution alpha=0.05, beta=0.20, Null Hypothesis=company claim leaker rate is correct, Alternate Hypothesis= the actual leaker rate is greater than or equal to company claimed leaker rate plus 2%)

Total Population Component Count	Component Claimed Leaker Rate (# leaking components/ # components in the population)										
	Up to 0.005	0.006 to 0.010	0.011 to 0.015	0.016 to 0.020	0.021 to 0.025	0.026 to 0.030	0.031 to 0.035	0.036 to 0.040	0.041 to 0.045	0.046 to 0.050	0.051 to 0.055
100 to 150	2	3	4	4	5	6	7	7	8	9	10
151 to 300	3	4	5	6	8	9	11	12	14	16	17
301 to 400	3	4	6	7	9	12	14	15	17	20	21
401 to 500	3	4	6	8	10	12	14	16	18	20	23
501 to 600	3	5	7	9	11	13	17	19	21	23	25
601 to 700	3	5	7	9	12	14	17	19	22	25	28
701 to 800	3	5	7	9	12	16	19	21	23	26	29
801 to 900	3	6	8	10	13	17	19	21	25	28	32
901 to 1,000	3	6	8	10	13	17	19	22	26	29	33
1,001 to 1,500	3	6	8	11	15	18	22	26	31	35	39
1,501 to 2,000	3	6	9	12	14	20	24	28	33	38	43
2,001 to 2,500	4	6	9	12	16	20	25	30	35	39	46
2,501 to 3,000	4	6	9	13	17	21	27	31	37	42	48
3,001 to 6,000	4	6	9	13	18	23	29	34	41	47	55
6,001 to 10,000	4	6	10	14	18	24	30	36	43	50	58
10,001 to 25,000	4	6	10	14	19	24	31	37	45	52	61
25,001 to 100,000	4	6	10	14	19	25	31	38	46	54	63
100,001 to 250,000	4	7	10	14	19	25	31	38	46	54	63

Sampling Plan Development

The sampling plan should be developed prior to conducting the site visit to avoid introducing bias in the selection of components to sample. The sampling plan should assure that sampling is from the population of interest. One would not want to sample just valves if one were interested in establishing the leaker rate for all component types, nor would one want to sample from only one area if one were interested in components from the entire site. Once a given component is sampled it will not be resampled during the evaluation. Statistically, this is called taking a simple random sample without replacement from a finite population.

Deciding how many components to sample has been addressed in Table 1. How we select those components is very important. There are several ways to obtain a simple random sample and there are ways to take a sample that results in anything but a simple random sample. If we need to sample 165 components and we went to the site, selected a given pipe run and sampled the first 165 components along that run, we would have taken a 'sample of convenience' resulting in information that could tell us about those 165 components. However, the results would be useless in making inferences from the sample to the larger population. Our evaluation demands that we estimate the population leaker rate based on a representative sample.

The way raffle tickets are chosen at raffles is an example of taking a simple random sample from a finite population without replacement. All the raffle tickets are placed in a hopper (finite population), someone spins the hopper, and then reaches into it and selects a ticket (simple random sample, each ticket has an equal chance of being selected). Once a ticket is pulled from the hopper, it is not returned to that hopper for that raffle (sample without replacement). The process is repeated until the requisite number of tickets have been drawn. We can do something similar at a site: we could get the master component log, and using a random number table, select components to sample from that list and then go into the field and find and sample the components whose numbers we had previously selected. This, however, is impractical.

The plots selected should be no smaller than 20 ft. x 20 ft. blocks for three reasons:

1) Each component of interest within the plot will be sampled, thus reducing the potential of bias in selecting components to be sampled within a plot.
2) It is easy to keep track of sampling progress in 20 ft. x 20 ft. blocks even at the most complex sites.
3) Small plots will ensure that multiple plots are selected for sampling.

CONDUCTING A LDAR PROGRAM EVALUATION

Activities Prior to Going On-site

1) **Obtain company LDAR monitoring reports for the last 4 to 6 monitoring cycles.** These reports should contain population component count by component type, service type and the number of leakers and calculated leaker rate for each component type. The monitoring results should also contain the leak definition and any information that would be pertinent to our properly conducting Method 21 monitoring at the site for the components of interest. Plot plans should also be obtained. These plot plans should contain latitude/longitude or some other type of location information for the area of the site that we are interested in sampling. The listing of various LDAR programs governing the components to be sampled should also be acquired.
2) **Calculate the sample size needed based on the population of interest.** Minimum sample size is determined based on applying company derived data to Table 1 above; Table 2 is used to determine the 'critical number of leakers'.

3) **Construct a sampling plan and have the predefined list of plots and location of plots on a plan identified.** Make sure extra plots are selected.

4) **Evaluate the previous company supplied leaker reports or records to determine compliance with the reporting and other requirements of the LDAR rules that apply**

On-site Investigation

1. Obtain a copy of the 'delay of repair' list from the company so that those components can be evaluated for timeliness of repair as they are encountered during the sampling.

   When a leak cannot be repaired within 15 days, the leak may be placed on a delay of repair list if repair of the component is technically infeasible or if the leak cannot be repaired without first shutting down the unit.

   REMEMBER: Every delay of repair leak must be accompanied by a physical sign-off sheet or physical signature from the person whose decision it was to place the leak on delay of repair. A physical signature is required for EACH leak; not one signature for a list of leaks. Require the RE to show this to you.

   Normally, DOR lists are made quarterly to reflect the latest quarter's monitoring. Compare the leaks from one DOR list from a given quarter to the DOR list from the next quarter. What is on the first list should be on the next list unless a shutdown has occurred in between.

   If the DOR items from the 1st quarter list are not on the 2nd quarter list and no shutdown have occurred in between, then that means they are no longer leaking and have been repaired. If so, the DOR leaks were repaired without a unit shutdown, which means they never should have been on the list to begin with and could have been repaired within the original 15-day period. Cite for failing to repair within 15 days.

   REMEMBER: Pumps may be assigned to a DOR list for no more than 6 months.
   REMEMBER: All valves on delay of repair must be monitored quarterly.

   DOR References: 40 CFR 60.482-9, 63.171, and 115.353(2) and (3).

2. **Implement the sampling plan and collect the data.**

   The company representative should be provided the opportunity of concurrent sampling, and if they elect to do so, their sample results should be recorded along with that collected by the investigator (Use Appendix A pg. 6). It is also recommended that the company representative be asked to calibrate their equipment against the investigator's standards to help identify any potential underlying problems with calibration standards. Collect at least the minimum number of samples called for by the sampling plan.

3. **After the completion of the sampling, conduct an on-site file review to evaluate other elements of the program.**

   A. Is the LDAR program in-house or contracted?

   B. If contracted, what's the name of the LDAR contractor?

   C. How long has the contractor been performing LDAR at the refinery?

D. When did they first take over the program?

   (Records of company sampling from previous monitoring periods should be acquired and date stamps of successive components sampled evaluated to see if the crew conducting sampling was allowing sufficient time to properly sample based on the characteristics of the equipment they used.)

E. How many daily on-site personnel does the contractor employ?

F. How many components are monitored quarterly and annually?

G. Describe supervision/oversight of the LDAR program.

H. Inquiry about any activities at the site that may have affected the population of components sampled, such as turnarounds, piping system rework, etc.

I. Name of LDAR Database.

J. Who operates the database daily?

K. Are LDAR monitoring records used to in preparing the annual EI submission?

L. Is stream speciation information included in the database for each component?

M. When was the last scheduled unit shutdown of the XXX & XXX process units?

N. Review of Method 21 Calibration records. This includes, daily and quarterly instrument calibration logs for each instrument used in the LDAR program and certificates of all calibration gas cylinders.

O. A list of unsafe to monitor (UTM) components for each process unit monitored. This should include why the component is categorized as UTM and a plan to monitor each UTM at times when it is safe to do so.

Determine whether all calibration, recordkeeping, repair, and reporting requirements have been met for the component population of interest.

Post Investigation Evaluation Results and Analysis

1) **Sum the total number of leakers from the data collection worksheets.** Compare the number of leakers found against the 'critical number of leakers' obtained from Table 2. If the sampled number of leaking components equals or exceeds the critical number of leakers, then do the following:

   a. Reject the hypothesis that the company leaker rate is the true leaker rate.

   b. Calculate the leaker rate based on our sample size and number of leakers found.

   c. Calculate the annual emissions for the population of components represented by the sample using screening range factors derived from the appropriate Environmental Protection Agency (EPA), New Source Review (NSR) or Emissions Inventory (EI) reference materials based on the company claimed value and our sample-based leaker rate. Include this information in the enforcement documentation.

If our sampling results in a number of leakers less than the critical number of leakers from Table 2, then we can conclude that there is insufficient evidence to reject the company claimed leaker rate.

2) **Evaluate the performance of the company against the other requirements of the LDAR programs for the population of components of interest. Document any other non-compliance issues.**

ENFORCEMENT GUIDANCE

Risks of the Program

The primary impediments to a successful implementation of the LDAR work practice standard include failure to properly cap open ended lines, failure to properly monitor the components, failure to repair the leaking components in a timely manner, and failing to keep the required detailed records. The risk from emissions that would have otherwise been reduced through the LDAR program are not minimal. For example, at one site located in a nonattainment area a collection of 351 components were subject to a LDAR program. If the operator of this LDAR program failed to properly calibrate the instrument prior to use which resulted in the inability of the equipment to properly sense the concentration of VOC around the components, then the emissions from those 351 components would amount to as much as 44.9 tons of air contaminants per year. However, if the same components were regulated by a properly implemented program, fugitive emissions would be limited to 1.3 tons per year. If the site is in a nonattainment area classified as severe with a major source threshold of 25 tons per year then these additional emissions due to the failure to implement the program properly would result in the equivalent of adding close to two major sources of VOCs to that air shed, without even considering the emissions offsets that would have been required for new sources in that area.

Nature of Violations

There are essentially three kinds or classes of violations in a LDAR program.

Violation Class 1: No program in place where one is required. This may be for the site as a whole or for a portion of the site, such as a new business unit added to the site but for which the LDAR program was never initiated.

Violation Class 2: Failure to properly conduct EPA Reference Method 21, the standard instrument method used to detect leaking components. This violation may stem from an improperly calibrated instrument, from failure to sample components long enough to allow the instrument to register the correct VOC concentration proximate to the leaking components, or from improper probe placement.

Violation Class 2a: Failure to meet substantive requirements of a LDAR program not related to recordkeeping or Method 21 performance. Examples include failure to cap open ended lines or to double block valves where required, failure to repair equipment tagged for turnaround ina timely manner and similar violations.

Violation Class 3: Failure to keep records of monitoring or calibration data.

The following two examples illustrate violation classes 1 and 3. Note that these examples are for illustrative purposes. In all instances, the final resolution of a violation situation must adhere to agency policy and guidance on enforcement matters.

Enforcement Example 1: Class 1 Violation

Company fails to conduct a monitoring program for two years where a monthly monitoring frequency is required. Air contaminant is VOC.

Steps to take:

a) Determine uncontrolled, annualized emissions.

- Tons/Yr per component type in given service = (Number of Components *EPA Average Emissions Factor)*(1-Controlled Emissions Factor)*8760 hrs/yr

Since no actual equipment monitoring data is available on which to quantify fugitive emissions, the EPA average factors must be used. Obtain the emissions factors from the most stringent rule to which collection of components is subject. Factors are published in EPA guidance and the TCEQ guidance identified in the section “Necessary Evaluator Background and Tools”. This is because many fugitive sources are subject to numerous LDAR programs. In many cases, companies voluntarily submit to LDAR programs in permitting to obtain VOC offsets. It is important to determine to which rules the collection is subject, and in what role (e.g., offset of non-attainment emissions) the emissions reductions play.

- Total emissions from the LDAR program = Sum of tons/yr per each component type in given service

b) Describe the context of the violation:

- The following should be conveyed in describing the violation:
  - If the annualized emissions total equals or exceeds the major source threshold for the geographic location;
  - If the source is in a nonattainment area, and the LDAR related emissions reductions were used to establish VOC offsets;
  - If the LDAR program emissions reductions were used to establish VOC offsets for Prevention of Significant Deterioration (PSD) review avoidance; or,
  - If the annualized emissions total equals or exceeds the PSD review threshold or the Nonattainment Review threshold for modifications requiring BACT review.
  - The date the program was originally required at the site.

Enforcement Example 2: Class 3 violation

If the company conducted monitoring, and failed to keep some of the records, but not enough to call the entire program into question, then the following should be conveyed in describing the violation:

If the company failed to keep any calibration records or leaker or leak repair records, then the violation should be treated as Example 1, above. If the company failed to keep some of the calibration records, then the description should include information on the relative importance of the records missed in assuring that the program was controlling emissions appropriately.

Post investigation procedures should be the same as with any on-site investigation. Written documentation should follow the established report criteria for investigations in the current version of the Report Writing Protocol. Conduct any follow-up communication or requests with the regulated entity as necessary. Complete CCEDS data entry. Conduct a quality review of the draft in accordance with current FODSOP investigation guidance.