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T Plant Comparison with 40 CFR 61, Subpart H, and Other Referenced Guidelines for Stack 291-T-1

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LIST OF ACRONYMS

AEA	alpha energy analysis
CAM	Continuous Air Monitoring
CY	calendar year
DCG	Derived Concentration Guide
DOP	di-octyl phthalate
EPA	U.S. Environmental Protection Agency
ERT	Emergency Response Team
HP	Health Physics
HPT	Health Physics Technician
LICCS	Laboratory Instrument Calibration Control System
LMCS	Laboratory Measurement Control System
MCA	multichannel analyzer
MEI	maximally exposed individual
NIST	National Institute of Standards and Technology
OHS	Occupational Health and Safety
OSCR	Off Standard Condition Report
PM	preventive maintenance
PNL	Pacific Northwest Laboratory
PUREX	Plutonium-Uranium Extraction
QA	quality assurance
QAPjP	Quality Assurance Project Plan
QAPP	quality assurance program plans
Re	Reynolds number
RL	U.S. Department of Energy Field Office, Richland
RPR	Radiological Problem Report
X/Q	atmospheric dispersion factor

T PLANT COMPARISON WITH 40 CFR 61, SUBPART H, AND OTHER REFERENCED GUIDELINES FOR STACK 291-T-1

40 CFR 61, SUBPART H, NATIONAL EMISSION STANDARDS FOR EMISSIONS OF RADIONUCLIDES OTHER THAN RADON FROM U.S. DEPARTMENT OF ENERGY FACILITIES

61.92 Standard. Emissions of radionuclides to the ambient air from Department of Energy facilities shall not exceed those amounts that would cause any member of the public to receive in any year an effective dose equivalent of 10 mrem/yr.

Dose calculations for atmospheric radionuclide releases from the Hanford Site for calendar year (CY) 1990 were performed by Pacific Northwest Laboratory (PNL) using the approved U.S. Environmental Protection Agency (EPA) CAP-88 computer model. Emissions from discharge points in the Hanford Site 100, 200, 300, 400, and 600 areas were calculated based on results of analyses of periodic sampling conducted at the discharge points. These calculated emissions were provided for inclusion in the CAP-88 model by area and by individual facility for those facilities having the potential to contribute more than 10% of the Hanford Site total or to result in an impact of greater than 0.1 mrem per year to the maximally exposed individual (MEI). Also included in the assessment of offsite dose modeling are the measured radioactive emissions from all Hanford Site stacks that have routine monitoring performed. Record sampling systems have been installed on all stacks and vents that use exhaust fans to discharge air that may potentially carry airborne radioactivity. Estimation of activity from ingrowth of long-lived radioactive progeny is not included in the CAP-88 model; therefore, the Hanford Site GENII code (Napier et al. 1988) was used to supplement the CAP-88 dose calculations. When the dose to the MEI located in the Ringold area was calculated, the effective dose equivalent from combined Hanford Site radioactive airborne emissions was shown to be 9.3E-03 mrem. This value was reported in the annual air emissions report prepared for the Hanford Site (RL 1991).

61.93 Emission monitoring and test procedures

(a) To determine compliance, radionuclide emissions shall be determined and effective dose equivalent values calculated suing EPA approved sampling procedures, computer models CAP-88 or AIRDOS-PC, or other procedures for which EPA has granted prior approval.

Dose calculations for atmospheric radionuclide releases from the Hanford Site for CY 1990 were performed by PNL using the approved EPA CAP-88 computer model. Emissions from discharge points in the Hanford Site 100, 200, 300, 400, and 600 areas were calculated based on results of analyses of periodic sampling conducted at the discharge points. These calculated emissions were provided for inclusion in the CAP-88 model by area and by individual facility for those facilities having the potential to contribute more than 10% of the Hanford Site total or to result in an impact of greater than 0.1 mrem per year to the MIE. Estimation of activity from ingrowth of long-lived radioactive progeny is not included in the CAP-88 model; therefore, the Hanford Site GENII code (Napier et

al. 1988) was used to supplement the CAP-88 dose calculations. When the dose to the maximally exposed individual located in the Ringold area was calculated, the effective dose equivalent from combined Hanford Site radioactive airborne emissions was shown to be 9.3E-03 mrem. This value was reported in the annual air emissions report prepared for the Hanford Site (RL 1991).

(b) Stacks shall be measured in accordance with the following requirements or other procedures for which EPA has granted prior approval:

(1) Effluent flow rate measurements shall be made using the following:

(i) Reference Method 2 of Appendix A to part 60 for large stacks.

Documentation: Drawings H-2-93415, *291-T-1 Stack Monitor Installation* and BPF-70174, *Concrete Stacks, The Rust Engineering Company* (WHC 1992a; Rust 1992).

Explanatory Remarks: The stack is 200 ft high with an inside base diameter of 7 ft. The stack tapers to an inside diameter of 5 ft at the top. The sample site is located at the 50-ft level of the stack. The sample site is located 40 ft downstream (or 6.6 average duct diameters) from the last disturbance.

(ii) Reference Method 2A of Appendix A to part 60 for small stacks.

(iii) Frequency of measurements shall depend upon the variability of the effluent flow rate. For variable flow rates, continuous or frequent flow rate measurements shall be made. For relatively constant flow rates only periodic measurements are necessary.

The flowrate is relatively constant and periodically measured.

(2) Radionuclides shall be directly monitored or extracted, collected and measured using the following:

(i) Reference Method 1 of Appendix A part 60 shall be used to select monitoring or sampling sites.

See Method 1 Section.

(ii) The effluent stream shall be directly monitored continuously with an in- line detector or representative samples of the effluent stream shall be withdrawn continuously from the sampling site following the guidance of ANSI N13.1-1969 (including Appendix A of ANSI N13.1).

See ANSI N13.1-1969 Section (ANSI 1969).

(3) When impractical to measure as in (b)(1) or to monitor or sample as in (b)(2), see this section for further requirements.

The RL has requested that the existing measurement system be approved as an alternative system instead of verbatim compliance. The additional requirements of this section are being met in part by this assessment.

(4) (i) Measurements shall be made at all release points which have a potential to discharge radionuclides into the air in quantities which could cause an effective dose equivalent (EDE) in excess of 1% of the standard. All

radionuclides which could contribute greater than 10% of the EDE shall be measured. For other release points with potential to release radionuclides, periodic confirmatory measurements shall be made.

Discharge points emitting airborne effluents having the potential to contain radionuclides in concentrations 10% of the Derived Concentration Guide Public Values (DCG-Public Value) given in DOE Order 5400.5, *Radiation Protection of the Public and the Environment*, Figure III-1, are sampled periodically (DOE 1990). For discharge points with average flowrates greater than 280 cubic meters per minute (m^3/min), analyses for specific radionuclides are required when the total concentrations of alpha-emitting or beta-emitting radionuclides exceed 10% of the DCG-Public Value for the most restrictive radionuclide not known to be absent from the stream. For discharge points with average flowrates less than 280 m^3/min, analyses for specific radionuclides are required when the total concentrations of alpha-emitting or beta-emitting radionuclides exceed 50% of the DCG-Public Value for the most restrictive radionuclide not known to be absent from the stream.

The chemical forms of radionuclides emitted determine the sampling media used. Particulates are sampled using fiber filters, volatile gases are collected on charcoal absorber or silver reactor media, tritium is collected in silica gel media, and ^{14}C is collected in charcoal cartridge media. Results of Hanford Site laboratory sample analyses are combined with discharge point average flowrate and operating schedule data to derive total emissions for each discharge point at the Hanford Site. These data were reported in the annual air emissions report for CY 1990 (RL 1991) prepared in compliance with 40 CFR 61.94(b) (EPA 1989b).

(ii) In evaluating the potential of a release point to discharge radionuclides into the air for the purposes of this section, the estimated rad release rates shall be based on the discharge of the effluent stream that would result if all pollution control equipment did not exist, but the facility operations were otherwise normal.

Offsite dose calculations were performed on all stacks (registered with the Washington Department of Health under Permit FF-01) without pollution control equipment and using the PNL unit dose conversions. A total of seven Hanford Site stacks exceeded the 0.1 mrem criterion and will require continuous monitoring in accordance with provisions of 40 CFR 61.93(b).

(5) Environmental measurements of rad air concentrations at critical receptor locations may be used instead of air dispersion calculations if:

(i) Air at point of measurement shall be continuously sampled.

(ii) Major contributing radionuclides to the EDE must be collected and measured.

(iii) Rad concentrations causing an EDE of 10% of the standard shall be readily detectable and distinguishable from background.

(iv) Net measured rad concentrations shall be compared to the concentration levels in Table 2 of App. E [part 61] to determine compliance with the standard. In the case of multiple rads, compliance is demonstrated if the value for all rad is less than the concentration levels in Table 2, and the sum of the fractions that result when each measured concentration value is divided by the value in Table 2 for each rad is less than 1.

(v) A program shall be conducted meeting the requirements of App. B, Method 114 [part 61].

(vi) Use of environmental measurements to demonstrate compliance with the standard if subject to prior approval of EPA.

61.94 Compliance and reporting.

(a) Compliance with this standard shall be determined by calculating the highest EDE to any member of the public at any offsite point where there is a residence, school, business, or office. Each facility shall submit an annual report to both EPA HQ and Regional by June 30 which includes monitoring results and dose calculations required by 61.43 (a) for the previous calendar year.

The Ringold location was chosen several years ago as the area where the offsite dose from all air pathways would be the highest for the MEI for the Hanford Site. The selection of Ringold was made because nearly all of the dose from air releases in recent years has been contributed by radionuclides from the Plutonium-Uranium Extraction (PUREX) Plant stack. The Ringold area is the closest farming area to the PUREX Plant, and it realistically matches the assumption that the MEI diet consists of 100% home-grown food. The Ringold area has historically been capable of producing all of the items in the MEI diet with the possible exception of cereal grain. The Ringold area lies very nearly in the path of the prevailing winds from the 200 East Area. The atmospheric dispersion factor (X/Q) at Ringold is historically within 10% to 20% of the maximum offsite X/Q value associated with 200 Areas releases. The maximum value usually occurs in an adjacent sector where there is no farming.

The U.S. Department of Energy Field Office, Richland (RL), provided the annual report for CY 1990 (RL 1991) to U.S. Department of Energy, Headquarters; EPA, Region X, personnel; and Washington Department of Health personnel in compliance with the regulatory deadline.

(b) The annual report shall also include: **(Future annual reports will also address the following requirements.)**

(1) Name and location of facility.

RL-91-10, Pages 1-6 through 1-29 (RL 1991). The Hanford Site summary is discussed on Pages 1-1 through 1-5.

(2) List of radioactive materials used at the facility.

RL-91-10, Table 2-1 on Pages 2-2 through 2-13. Please also refer to explanatory remarks for 40 CFR 61.93(4)(i) above.

(3) Description of handling and processing of rad materials at the facility.

RL-91-10, Pages 1-6 through 1-29.

(4) List of the stacks and vents (or other points where radioactive materials are released to the atmosphere.

RL-91-10, Pages 1-6 through 1-29.

(5) A description of the effluent controls that are used on each stack vent of release point, and an estimate of the efficiency of each control device.

RL-91-10, Table 2-1 on Pages 2-2 through 2-13.

(6) Distances from the points of release to the nearest residence, school, business or office and the nearest farms producing vegetables, milk and meat.

RL-91-10, Tables 3-2 and 3-3, in Section 3. These tables show the CAP-88 Dose Estimates for the Offsite Individual at Ringold Exposed to Radionuclide Emissions from Hanford Site During 1990. Please also refer to explanatory remarks for 40 CFR 61.94 above.

(7) The values used for all other input parameters for the computer models (meteorological data) and the source of these data.

RL-91-10. Input parameters are shown in Table 2-1, pages 2-2 through 2-13. Annual average dispersion factors around the 100, 200, 300, and 400 areas during 1990 are given in Tables 3-5 through 3-8. These tables use site-specific measurements of the occurrence frequencies for wind speed, wind direction, and atmospheric stability. The products of the dispersion models are annual average dispersion factors (X/Q', in units of Ci/m^3 per Ci/s or s/m^3) that, when combined with annual average release rates, will predict average radionuclide air concentrations for the year.

(8) A brief description of all construction and modifications which were completed in the calendar year for which the report is prepared, but for which the requirement to apply for approval to construct or modify was waived under 61.96.

RL-91-10, Section 3.5.2, discusses an "Application For Approval of Construction of the In Situ Vitrification Demonstration Project."

(9) Each report shall be signed and dated by a corporate officer or public official in charge of the facility and containing a declaration of belief of accuracy and truth of the report.

RL-91-10, Page 3-13, signed by John D. Wagoner, Manager, RL.

(c) If the facility is not in compliance with the emission limits of 61.96 in the calendar year, reporting the information in (b) [above] must be done on a monthly basis starting immediately following the noncompliance annual report. Monthly reports shall also include:

The Hanford Site is in compliance with 40 CFR 61.96; hence, this section is not applicable.

(1) Controls or other changes installed to bring the facility into compliance.

(2) If the facility is under a judicial or administrative enforcement decree, the report will describe the facility performance under the terms of the decree.

(d) If this information is classified, it will be made available to EPA separately and handled in accordance with regulations.

This information is not classified; hence, this section is not applicable.

61.95 Recordkeeping requirements.

All facilities must maintain records documenting the source of input parameters including the results of all measurements, calculations, analytical methods, and procedure for determining EDE. Sufficient information to allow an independent auditor to verify the accuracy should be kept. The records must be kept at the site for at least five years and must be made available upon request to an authorized representative.

All records and data used in the generation and verification of regulatory reports are controlled in accordance with WHC-CM-4-2, QR 4.0, "Document Control," and QR 17.0, "Quality Assurance Records" (WHC 1992b).

61.96 Applications to construct or modify.

In addition to construction as defined under 40 CFR 61 A, any fabrication, erection or installation of a new building or structure within a facility that emits radionuclides is also defined as new construction for purposes of 40 CFR 61 A.

(b) Application for approval [61.07] or notification of startup [61.09] does not need to be filed for any new construction or modification if the EDE caused by all emissions from the new construction or modification is less than 1% of the standard of 61.92. EDE shall be calculated using the source term derived from Appendix D as input to dispersion described in 61.93. A facility is eligible for this exemption only if it is in compliance based on its last annual report.

(c) Conditions to approvals granted under 61.08 will not contain requirements for post approval reporting on operating conditions beyond those specified in 61.94.

61.97 Exemption from the reporting and testing requirements of 40 CFR 61.10.

All facilities designated under subpart H are exempt from the reporting requirements of 40 CFR 61.10.

40 CFR 60, APPENDIX A, REFERENCE METHOD 2, DETERMINATION OF STACK GAS VELOCITY AND VOLUMETRIC FLOW RATE (TYPE S PITOT TUBE)

1.0 Principle and Applicability

1.1 Principle. The average gas velocity in a stack is determined from the gas density and from measurement of the average velocity head with a Type S (Stausscheibe or reverse type) pitot tube.

Documentation: **7-GN-56 (WHC 1991a).**

Response: **Average gas velocity is determined by averaging the results of exhaust duct traverses which have been conducted using a standard pitot tube and typically an Air Neotronics Limited MP Series 4 Autozero Digital Micromanometer[1] (see description of this latter instrument in Section 2.2 below). Procedure 7-GN-56 indicates that traverse locations are determined in accordance with Section 9 of the American Industrial Hygiene Association *Industrial Ventilation* manual rather than EPA Method 1.**

1.2 Applicability. This method is applicable for measurement of the average velocity of a gas stream and for quantifying gas flow.

This procedure is not applicable at measurement sites which fail to meet the criteria of Method 1, Section 2.1. Also, the method cannot be used for direct measurement in cyclonic or swirling gas streams; Section 2.4 of Method 1 shows how to determine cyclonic or swirling flow conditions. When unacceptable conditions exist, alternative procedures, subject to the approval of the Administrator, U.S. Environmental Protection Agency, must be employed to make accurate flow rate determinations; examples of such alternative procedures are: (1) to install straightening vanes; (2) to calculate the total volumetric flow rate stoichiometrically; or (3) to move to another measurement site at which the flow is acceptable.

Documentation: **Drawings H-2-93415, *291-T-1 Stack Monitor Installation* and BPF-70174, *Concrete Stacks, The Rust Engineering Company* (WHC 1992a; Rust 1992).**

Explanatory Remarks: **The stack is 200 ft high with an inside base diameter of 7 ft. The stack tapers to an inside diameter of 5 ft at the top. The sample site is located at the 50-ft level of the stack. The sample site for continuous monitoring is located 40 ft downstream (or 6.6 average duct diameters) from the last disturbance.**

2.0 Apparatus

Specifications for the apparatus are given below. Any other apparatus that has been demonstrated (subject to approval of the Administrator) to be capable of meeting the specifications will be considered acceptable.

2.1 Type S Pitot Tube. The Type S pitot tube (Figure 2-1) shall be made of metal tubing (e.g., stainless steel). It is recommended that the external tubing diameter (dimension D_t Figure 2-2b) be between 0.48 and 0.95 centimeter (3/16 and 3/8 inch). There shall be an equal distance from the base of each leg of the pitot tube to its face-opening plane (dimensions P_A and P_B Figure 2-2b); it is recommended that this distance be between 1.05 and 1.50 times the external tubing diameter. The face openings of the pitot tube shall, preferably, be aligned as shown in Figure 2-2; however, slight misalignments of the openings are permissible (see Figure 2-3).

---

[1]Air Neotronics Limited MP Series 4 Autozero Digital Micromanometer is a product of Air Neotronics Limited.

The Type S pitot tube shall have a known coefficient, determined as outlined in Section 4. An identification number shall be assigned to the pitot tube; this number shall be permanently marked or engraved on the body of the tube.

A standard pitot tube may be used instead of a Type S, provided that it meets the specifications of Sections 2.7 and 4.2: note, however, that the static and impact pressure holes of standard pitot tubes are susceptible to plugging in particulate-laden gas streams. Therefore, whenever a standard pitot tube is used to perform a traverse adequate proof must be furnished that the openings of the pitot tube have not plugged up during the traverse period; this can be done by taking a velocity head ΔP reading at the final traverse point, cleaning out the impact and static holes of the standard pitot tube by "back-purging" with pressurized air, and then taking another ΔP reading. If the ΔP readings made before and after the air purge are the same (± 5 percent), the traverse is acceptable. Otherwise, reject the run. Note that if ΔP at the final traverse point is unsuitably low, another point may be selected. If "back-purging" at regular intervals is part of the procedure, then comparative ΔP readings shall be taken, as above, for the last two back purges at which suitably high ΔP readings are observed.

Documentation: **7-GN-56 (WHC 1991a).**

Response: **The standard pitot tube is used in conjunction with a digital micromanometer to determine stack velocities. Document 7-GN-56 does not reference procedures used to prove that pitot tube openings have plugged during velocity measurements, however, since the measurement locations are positioned downstream from HEPA filter banks, it is unlikely that plugging of tube openings occurs.**

2.2 Differential Pressure Gauge. An inclined manometer or equivalent device is used. Most sampling trains are equipped with a 10-in. (water column) inclined-vertical manometer, having 0.01-in. H_2O divisions on the 0-to 1-in. inclined scale, and 0.1-in. H_2O divisions on the 1- to 10-in. vertical scale. This type of manometer (or other gauge of equivalent sensitivity) is satisfactory for the measurement of ΔP values as low as 1.3 mm (0.05 in.) H_2O. However, a differential pressure gauge of greater sensitivity shall be used (subject to the approval of the Administrator), if any of the following is found to be true: (1) the arithmetic average of all ΔP readings at the traverse points in the stack is less than 1.3 mm (0.05 in.) H_2O; (2) for traverses of 12 or more points, more than 10 percent of the individual ΔP readings are below 1.3 mm (0.05 in.) H_2O; (3) for traverses of fewer than 12 points, more than one ΔP reading is below 1.3 mm (0.05 in.) H_2O. Citation 18 in Section 6 describes commercially available instrumentation for the measurement of low-range gas velocities.

As an alternative to criteria (1) through (3) above, the following calculation may be performed to determine the necessity of using a more sensitive differential pressure gauge:

(see equation 40 CFR Pt. 60 App. A, Meth. 2, page 645)

If T is greater than 1.05, the velocity head data are unacceptable and a more sensitive differential pressure gauge must be used.

NOTE: If differential pressure gauges other than inclined manometers are used (e.g., magnehelic gauges) their calibration must be checked after each test series. To check the calibration of a differential pressure gauge, compare ΔP readings of the gauge with those of a gauge-oil manometer at a minimum of three points, approximately representing the range of ΔP values in the stack. If, at each point, the values of ΔP as read by the differential pressure gauge and gauge-oil manometer agree to within 5 percent, the differential pressure gauge shall be considered to be in proper calibration. Otherwise, the test series shall either be voided, or procedures to adjust the measured ΔP values and final results shall be used subject to the approval of the Administrator.

Documentation: **7-GN-56, manufacturer's product literature.**

Response: **An Air Neotronics MP Series 4 Autozero Digital Micromanometer is typically used to determine differential pressure and flow velocity. This instrument consists of a differential capacitance transducer and internal electronics which allow the instrument to calculate and display corrected velocity readings directly from pitot tube probes. Dynamic pressure**

signals from pitot static and total head tubes are automatically corrected within the instrument and displayed in feet per minute. The instrument is capable of resolving pressure to 0.001 in. H_2O (according to manufacturer's literature).

Procedure 7-GN-56 requires that the instrument carry a current calibration sticker, traceable to NIS&T. No post test series comparison against a gauge-oil manometer are indicated in Procedure 7-GN-56.

2.3 Temperature Gauge. A thermocouple, liquid-filled bulb thermometer, bimetallic thermometer, mercury-in-glass thermometer, or other gauge, capable of measuring temperature to within 1.5 percent of the minimum absolute stack temperature shall be used. The temperature gauge shall be attached to the pitot tube such that the sensor tip does not touch any metal; the gauge shall be in an interference-free arrangement with respect to the pitot tube face openings (see Figure 2-1 and also Figure 2-7 in Section 4). Alternate positions may be used if the pitot tube-temperature gauge system is calibrated according to the procedure of Section 4. Provided that a difference of not more than 1 percent in the average velocity measurement is introduced, the temperature gauge need not be attached to the pitot tube; this alternative is subject to the Approval of the Administrator.

Documentation: 7-GN-56.

Response: Temperatures are not measured. The density program internal to the micromanometer is set for standard conditions (70 °F and 29.92 in. mercury). This introduces minimal error in the determination of stack velocity provided the temperature of the air stream varies no more than 30 °F from standard air, the altitude of the site does not exceed 1,000 ft above sea level, or the moisture content of the air is 0.02 lb/lb of dry air or less.

2.4 Pressure Probe and Gauge. A piezometer tube and mercury- or water-filled U-tube manometer capable of measuring stack pressure to within 2.5 mm (0.1 in.) Hg is used. The static tap of a standard type pitot tube or one leg of a Type S pitot tube with the face opening planes positioned parallel to the gas flow may also be used as the pressure probe.

Documentation: 7-GN-56.

Response: The static tap of a standard pitot tube is used to measure stack pressure.

2.5 Barometer. A mercury, aneroid, or other barometer capable of measuring atmospheric pressure to within 2.5 mm Hg (0.1 in. Hg) may be used. In many cases, the barometric reading may be obtained from a nearby National Weather Service station, in which case the station value (which is the absolute barometric pressure) shall be requested and an adjustment for elevation differences between the weather station and the sampling point shall be applied at a rate of minus 2.5 mm (0.1 in.) Hg per 30-meter (100 foot) elevation increase or vice-versa for elevation decrease.

Documentation: 7-GN-56.

Response: Barometric pressures are not measured. The density program internal to the micromanometer is set for standard conditions (70 °F and 29.92 in. mercury). This introduces minimal error in the determination of stack velocity provided the temperature of the air stream varies no more than 30 °F from standard air, the altitude of the site does not exceed 1,000 ft above sea level, or the moisture content of the air is 0.02 lb/lb of dry air or less.

2.5 Alternative Measurement Site Selection Procedure. This alternative applies to sources where measurement locations are less than 2 equivalent stack or duct diameters downstream or less than one-half duct diameter upstream from a flow disturbance. The alternative should be limited to ducts larger than 24 in. in diameter where blockage and wall effects are minimal. A directional flow-sensing probe is used t measure pitch and yaw angles of the gas flow at 40 or more traverse points; the resultant angle is calculated and compared with acceptable criteria for mean and standard deviation.

NOTE: Both the pitch and yaw angles are measured from a line passing through the traverse point and parallel to the stack axis. The pitch angle is the angle of the gal flow component in the plane than INCLUDES the traverse line and is parallel to the stack axis. The yaw angle is the angle of the gas flow component in the plant PERPENDICULAR to the traverse line at the traverse point and is measured from the line passing through the traverse point and parallel to the stack axis.

Response: **Not applicable. The measurement site is more than two equivalent duct diameters downstream and one-half equivalent duct diameter upstream from the nearest disturbances.**

2.6 Gas Density Determination Equipment. Method 3 equipment, if needed (see Section 3.6), to determine the stack gas dry molecular weight, and Reference Method 4 or Method 5 equipment for moisture content determination; other methods may be used subject to approval of the Administrator.

Documentation: **7-GN-56.**

Response: **Stack gas moisture content is not determined. Depending on process conditions, however, the correction to reported velocity values derived from the actual measurement of both stack dry molecular weight and moisture content may be minimal.**

2.7 Calibration Pilot Tube. When calibration of the Type S pitot tube is necessary (see Section 4), a standard pitot tube is used as a reference. The standard pitot tube shall, preferably, have a known coefficient, obtained either (1) directly from the National Bureau of Standards, Route 270, Quince Orchard Road, Gaithersburg, Maryland, or (2) by calibration against another standard pitot tube with an NBS-traceable coefficient. Alternatively, a standard pitot tube designed according to the criteria given in 2.7.1 through 2.7.5 below and illustrated in Figure 2-4 (see also Citations 7, 8, and 17 in Section 6) may be used. Pitot tubes designed according to these specifications will have baseline coefficients of about 0.99 ± 0.01.

Documentation: **7-GN-56.**

Response: **Not applicable, since the Type S pitot tube is not used to measure velocity.**

2.7.1 Hemispherical (shown in Figure 2- 4), ellipsoidal, or conical tip.

Documentation: **Manufacturer's print 72-000031-00 (F. W. Dwyer Manufacturing Company, Michigan City, Indiana).**

Response: **The standard pitot tubes used are procured commercially from sources such as F. W. Dwyer Manufacturing Co. They are constructed to standards outlined in Section 2.7 and contain hemispherical tips.**

2.7.2 A minimum of six diameters straight run (based upon D, the external diameter of the tube) between the tip and the static pressure holes.

Documentation: **Manufacturer's print 72-000031-00 (F. W. Dwyer Manufacturing Company, Michigan City, Indiana).**

Response: The standard pitot tubes used are procured commercially from sources such as F. W. Dwyer Manufacturing Co. They are constructed to standards outlined in this section. A minimum of six diameters straight run between tip and static pressure holes is provided.

2.7.3 A minimum of eight diameters straight run between the static pressure holes and the centerline of the external tube, following the 90 degree bend.

Documentation: Manufacturer's print 72-000031-00 (F. W. Dwyer Manufacturing Company, Michigan City, Indiana).

Response: The standard pitot tubes used are procured commercially from sources such as F. W. Dwyer Manufacturing Co. They are constructed to standards outlined in this section. A minimum of eight diameters straight run between the static pressure holes and the centerline of the external tube is provided.

2.7.4 Static pressure holes of equal size (approximately 0.1 D), equally spaced in a piezometer ring configuration.

Documentation: Manufacturer's print 72-000031-00 (F. W. Dwyer Manufacturing Company, Michigan City, Indiana).

Response: The standard pitot tubes used are procured commercially from sources such as F. W. Dwyer Manufacturing Co. They are constructed to standards outlined in this section. The above criteria are met by the manufacturer.

2.7.5 Ninety degree bend, with curved or mitered junction.

Documentation: Manufacturer's print 72-000031-00 (F. W. Dwyer Manufacturing Company, Michigan City, Indiana).

Response: The standard pitot tubes used are procured commercially from sources such as F. W. Dwyer Manufacturing Co. They are constructed to standards outlined in this section. The above criteria are met by the manufacturer.

2.8 Differential Pressure Gauge for Type S Pitot Tube Calibration. An inclined manometer or equivalent is used. If the single-velocity calibration technique is employed (see Section 4.1.2.3), the calibration differential pressure gauge shall be readable to the nearest 0.13 mm H_2O (0.005 in. H_2O). For multivelocity calibration, the gauge shall be readable to the nearest 0.13 mm H_2O (0.005 in. H_2O) for ΔP values between 1.3 and 25 mm H_2O (0.05 and 1.0 in. H_2O), and to the nearest 1.3 mm H_2O (0.05 in. H_2O) for ΔP values above 25 mm H_2O (1.0 in. H_2O). A special, more sensitive gauge will be required to read ΔP values below 1.3 mm H_2O [0.05 in. H_2O] (see Citation 18 in Section 6).

Documentation: 7-GN-56.

Response: Not applicable. The Type S pitot tube is not used.

3.0 Procedure

Procedures described in these sections shall be used to determine the stack velocity when the Type S pitot tube is used.

3.1 Set up the apparatus as shown in Figure 2-1. Capillary tubing or surge tanks installed between the manometer and pitot tube may be used to dampen ΔP fluctuations. It is recommended, but not required, that a pretest leak-check be conducted, as follows: (1) blow through the pitot impact opening until at least 7.6 cm (3 in.) H_2O velocity pressure registers on the manometer; then, close off the impact opening. The pressure shall remain stable for at least 15 seconds; (2) do the same for the static pressure side, except using suction to obtain the minimum of 7.6 cm (3 in.) H20. Other leak check procedures, subject to the approval of the Administrator, may be used.

Documentation: **7-GN-56.**

Response: **Not applicable. The Type S pitot tube is not used.**

3.2 Level and zero the manometer. Because the manometer level and zero may drift due to vibrations and temperature changes, make periodic checks during the traverse. Record all necessary data as shown in the example data sheet (Figure 2-5).

Documentation: **7-GN-56.**

Response: **Not applicable. The Type S pitot tube is not used.**

3.3 Measure the velocity head and temperature at the traverse points specified by Method 1. Ensure that the proper differential pressure gauge is being used for the range of ΔP values encountered (see Section 2.2). If it is necessary to change to a more sensitive gauge, do so, and remeasure the ΔP and temperature readings at each traverse point. Conduct a post-test leak-check (mandatory), as described in Section 3.1 above, to validate the traverse run.

Documentation: **7-GN-56.**

Response: **Not applicable. The Type S pitot tube is not used.**

3.4 Measure the static pressure in the stack. One reading is usually adequate.

Documentation: **7-GN-56.**

Response: **Not applicable. The Type S pitot tube is not used.**

3.5 Determine the atmospheric pressure.

Documentation: **7-GN-56.**

Response: **Not applicable. The Type S pitot tube is not used.**

3.6 Determine the stack gas dry molecular weight. For combustion processes or processes that emit essentially CO_2, O_2, CO and N_2, use Method 3. For processes emitting essentially air, an analysis need not be conducted; use a dry molecular weight of 29.0. For other processes, other methods, subject to the approval of the Administrator, must be used.

Documentation: **7-GN-56.**

Response: **Not applicable. The Type S pitot tube is not used.**

3.7 Obtain the moisture content from Reference Method 4 (or equivalent) or from Method 5.

Documentation: **7-GN-56.**

Response: **Not applicable. The Type S pitot tube is not used.**

3.8 Determine the cross-sectional area of the stack or duct at the sampling location. Whenever possible, physically measure the stack dimensions rather than using blueprints.

Documentation: **7-GN-56.**

Response: **Not applicable. The Type S pitot tube is not used.**

4.0 Calibration

4.1 Type S Pitot Tube. Before its initial use, carefully examine the Type S pitot tube in top, side, and end views to verify that the face openings of the tube are aligned within the specifications illustrated in Figure 2-2 or 2-3. The pitot tube shall not be used if it fails to meet these alignment specifications.

After verifying the face opening alignment, measure and record the following dimensions of the pitot tube: (a) the external tubing diameter (dimension D_t, Figure 2-2b); and (b) the base-to-opening plane distances (dimensions P_A, and P_B, Figure 2-2b). If D_t is between 0.48 and 0.95 cm (3/16 and 3/8 in.) and if P_A, and P_B, are equal and between 1.05 and 1.50 D_t, there are two possible options: (1) the pitot tube may be calibrated according to the procedure outlined in Sections 4.1.2 through 4.1.5 below, or (2) a baseline (isolated tube) coefficient value of 0.84 may be assigned to the pitot tube. Note, however, that if the pitot tube is part of an assembly, calibration may still be required, despite knowledge of the baseline coefficient value (see Section 4.1.1).

If D_t, P_A, and P_B, are outside the specified limits, the pitot tube must be calibrated as outlined in 4.1.2 through 4.1.5 below.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.1 Type S Pitot Tube Assemblies. During sample and velocity traverses, the isolated Type S pitot tube is not always used; in many instances, the pitot tube is used in combination with other source-sampling components (thermocouple, sampling probe, nozzle) as part of an "assembly." The presence of other sampling components can sometimes affect the baseline value of the Type S pitot tube coefficient (Citation 9 in Section 6); therefore an assigned (or otherwise known) baseline coefficient value may or may not be valid for a given assembly. The baseline and assembly coefficient values will be identical only when the relative placement of the components in the assembly is such that aerodynamic interference effects are eliminated. Figures 2-6 through 2-8 illustrate interference-free component arrangements for Type S pitot tubes having external tubing diameters between 0.48 and 0.95 cm (3/16 and 3/8 in.). Type S pitot tube assemblies that fail to meet any or all of the specifications of Figures 2-6 through 2-8 shall be calibrated according to the procedure outlined in Sections 4.1.2 through 4.1.5 below, and prior to calibration, the values of the intercomponent spacings (pitot-nozzle, pitot-thermocouple, pitot-probe sheath) shall be measured and recorded.

NOTE: Do not use any Type S pitot tube assembly which is constructed such that the impact pressure opening plane of the pitot tube is below the entry plane of the nozzle (see Figure 2-6b).

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.2 Calibration Setup. If the Type S Pitot tube is to be calibrated, one leg of the tube shall be permanently marked A, and the other, B. Calibration shall be done in a flow system having the following essential design features:

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.2.1 The flowing gas stream must be confined to a duct of definite cross- sectional area, either circular or rectangular. For circular cross-sections, the minimum duct diameter shall be 30.5

cm (12 in.); for rectangular cross-sections, the width (shorter side) shall be at least 25.4 cm (10 in.).

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.2.2 The cross-sectional area of the calibration duct must be constant over a distance of 10 or more duct diameters. For a rectangular cross-section, use an equivalent diameter, calculated from the following equation, to determine the number of duct diameters:

$$D_e = \frac{2LW}{(L+W)} \qquad 2\text{-}1$$

Where:

D_t=Equivalent diameter
L =Length
W =Width

To ensure the presence of stable, fully developed flow patterns at the calibration site, or "test section," the site must be located at least eight diameters downstream and two diameters upstream from the nearest disturbances.

NOTE: The eight- and two-diameter criteria are not absolute; other test section locations may be used (subject to approval of the Administrator), provided that the flow at the test site is stable and demonstrably parallel to the duct axis.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.2.3 The flow system shall have the capacity to generate a test-section velocity around 915 m/min (3,000 ft/min). This velocity must be constant with time to guarantee steady flow during calibration. Note that Type S pitot tube coefficients obtained by single-velocity calibration at 915 m/min (3,000 ft/min) will generally be valid to within ± 3 percent for the measurement of velocities above 305 m/min (1,000 ft/min) and to within ± 5 to 6 percent for the measurement of velocities between 180 and 305 m/min (600 and 1000 ft/min). If a more precise correlation between Cp and velocity is desired, the flow system shall have the capacity to generate at least four distinct time-invariant test-section velocities covering the velocity range from 180 and 1,525 m/min (600 to 5,000 ft/min), and calibration data shall be taken at regular velocity intervals over this range (see Citations 9 and 14 in Section 6 for details).

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.2.4 Two entry ports, one each for the standard and Type S pitot tubes, shall be cut in the test section; the standard pitot entry port shall be located slightly downstream of the Type S port, so that

the standard and Type S impact openings will lie in the same cross-sectional plane during calibration. To facilitate alignment of the pitot tubes during calibration, it is advisable that the test section be constructed of plexiglas or some other transparent material.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.3 Calibration Procedure. Note that this procedure is a general one and must not be used without first referring to the special considerations presented in Section 4.1.5. Note also that this procedure applies only to single-velocity calibration. To obtain calibration data for the A and B sides of the Type S pitot tube, proceed as follows:

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.3.1 Make sure that the manometer is properly filled and that the oil is free from contamination and is of the proper density. Inspect and leak-check all pitot lines; repair or replace if necessary.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.3.2 Level and zero the manometer. Turn on the fan and allow the flow to stabilize. Seal the Type S entry port.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.3.3 Ensure that the manometer is level and zeroed. Position the standard pitot tube at the calibration point (determined as outlined in Section 4.1.5.1), and align the tube so that its tip is pointed directly into the flow. Particular care should be taken in aligning the tube to avoid yaw and pitch angles. Make sure that the entry port surrounding the tube is properly sealed.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.3.4 Read ΔP_{std} and record its value in a data table similar to the one shown in Figure 2-9. Remove the standard pitot tube from the duct and disconnect it from the manometer. Seal the standard entry port.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.3.5 Connect the Type S pitot tube to the manometer. Open the Type S entry port. Check the manometer level and zero. Insert and align the Type S pitot tube so that its A side impact opening is at the same point as was the standard pitot tube and is pointed directly into the flow. Make sure that the entry port surrounding the tube is properly sealed.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.3.6 Read ΔP, and enter its value in the data table. Remove the Type S pitot tube from the duct and disconnect it from the manometer.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.3.7 Repeat steps 4.1.3.3 through 4.1.3.6 above until three pairs of ΔP readings have been obtained.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.3.8 Repeat steps 4.1.3.3 through 4.1.3.7 above for the B side of the Type S pitot tube.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.3.9 Perform calculations, as described in Section 4.1.4 below.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.4 Calculations.

4.1.4.1 For each of the six pairs of ΔP readings (i.e., three from side A and three from side B) obtained in Section 4.1.3 above, calculate the value of the Type S pitot tube coefficient as follows:

$$C_{p(s)} = C_{p(std)} \sqrt{\frac{\Delta p_{std}}{\Delta p_s}} \qquad 2-2$$

Where:

$C_{p(s)}$ = Type S Pitot tube coefficient

$C_{p(std)}$ = Standard Pitot tube coefficient: use 0.99 if the coefficient is unknown and the tube is designed according to the criteria of Sections 2.7.1 to 2.7.5 of this method.

ΔPstd = Velocity head measured by the standard pitot tube, cm H_2O (in. H_2O)

ΔPs = Velocity head measured by the Type S pitot tube, cm H_2O (in. H_2O)

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.4.2 Calculate Cp (side A), the mean A side coefficient, and C_p (side B), the mean B side coefficient: calculate the difference between these two average values.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.4.3 Calculate the deviation of each of the three A-side values of $C_p(s)$ from C_p (side A), and the deviation of each B-side value of $C_p(s)$ from C_p (side B). Use the following equation:

$$Deviation = C_{p(s)} - \overline{C_p}(A \text{ or } B) \qquad 2\text{-}3$$

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.4.4 Calculate α, the average deviation from the mean, for both the A and B sides of the pitot tube. Use the following equation:

$$\sigma(side\ A \text{ or } B) = \frac{\sum_{1}^{3} \left| C_{p(s)} - \overline{C_p}(A \text{ or } B) \right|}{3} \qquad 2\text{-}4$$

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.4.5 Use the Type S pitot tube only if the values of σ (side A) and σ (side B) are less than or equal to 0.01 and if the absolute value of the difference between C_p (A) and C_p (B) is 0.01 or less.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.5 Special considerations.

4.1.5.1 Selection of calibration point.

4.1.5.1.1 When an isolated Type S pitot tube is calibrated, select a calibration point at or near the center of the duct, and follow the procedures outlined in Section 4.1.3 and 4.1.4 above. The Type S pitot coefficients so obtained, i.e., C_p (side A) and C_p, (side B), will be valid, so long as either: (1) the isolated pitot tube is used; or (2) the pitot tube is used with other components (nozzle, thermocouple, sample probe) in an arrangement that is free from aerodynamic interference effects (see Figures 2-6 through 2-8).

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.5.1.2 For Type S pitot tube-thermocouple combinations (without sample probe), select a calibration point at or near the center of the duct, and follow the procedures outlined in Sections 4.1.3 and 4.1.4 above. The coefficients so obtained will be valid so long as the pitot tube-thermocouple combination is used by itself or with other components in an interference-free arrangement (Figures 2-6 and 2-8).

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.5.1.3 For assemblies with sample probes, the calibration point should be located at or near the center of the duct; however, insertion of a probe sheath into a small duct may cause significant cross-sectional area blockage and yield incorrect coefficient values (Citation 9 in Section 6). Therefore, to minimize the blockage effect, the calibration point may be a few inches off-center if necessary. The actual blockage effect will be negligible when the theoretical blockage, as determined by a projected-area model of the probe sheath, is 2 percent or less of the duct cross-sectional area for assemblies without external sheaths (Figure 2-10a), and 3 percent or less for assemblies with external sheaths (Figure 2-10b).

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.5.2 For those probe assemblies in which pitot tube-nozzle interference is a factor (i.e., those in which the pitot-nozzle separation distance fails to meet the specification illustrated in Figure 2-6a), the value of $C_p(s)$ depends upon the amount of free-space between the tube and nozzle, and therefore is a function of nozzle size. In these instances, separate calibrations shall be performed with each of the commonly used nozzle sizes in place. Note that the single-velocity calibration technique is acceptable for this purpose, even though the larger nozzle sizes (>0.635 cm or 1/4 in.) are not ordinarily used for isokinetic sampling at velocities around 915 m/min (3,000 ft/min), which is the calibration velocity; note also that it is not necessary to draw an isokinetic sample during calibration (see Citation 19 in Section 6).

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.5.3 For a probe assembly constructed such that its pitot tube is always used in the same orientation, only one side of the pitot tube need be calibrated (the side which will face the flow). The pitot tube must still meet the alignment specifications of Figure 2-2 or 2-3, however, and must have an average deviation (σ) value of 0.01 or less (see Section 4.1.4.4).

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.6 Field Use and Recalibration.

4.1.6.1 Field Use.

4.1.6.1.1 When a Type S pitot tube (isolated tube or assembly) is used in the field, the appropriate coefficient value (whether assigned or obtained by calibration) shall be

used to perform velocity calculations. For calibrated Type S pitot tubes, the A side coefficient shall be used when the A side of the tube faces the flow, and the B side coefficient shall be used when the B side faces the flow; alternatively, the arithmetic average of the A and B side coefficient values may be used, irrespective of which side faces the flow.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.6.1.2 When a probe assembly is used to sample a small duct (12 to 36 in. in diameter), the probe sheath sometimes blocks a significant part of the duct cross-section, causing a reduction in the effective value of $C_p(s)$. Consult Citation 9 in Section 6 for details. Conventional pitot-sampling probe assemblies are not recommended for use in ducts having inside diameters smaller than 12 inches (Citation 16 in Section 6).

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.6.2 Recalibration.

4.1.6.2.1 Isolated Pitot tubes. After each field use, the pitot tube shall be carefully reexamined in top, side, and end views. If the pitot face openings are still aligned within the specifications illustrated in Figure 2-2 or 2-3, it can be assumed that the baseline coefficient of the pitot tube has not changed. If, however, the tube has been damaged to the extent that it no longer meets the specifications of Figure 2-2 or 2-3, the damage shall either be repaired to restore proper alignment of the face openings or the tube shall be discarded.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.1.6.2.2 Pitot tube Assemblies. After each field use, check the face opening alignment of the pitot tube, as in Section 4.1.6.2.1; also, remeasure the intercomponent spacings of the assembly. If the intercomponent spacings have not changed and the face opening alignment is acceptable, it can be assumed that the coefficient of the assembly has not changed. If the face opening alignment is no longer within the specifications of Figures 2-2 or 2-3, either repair the damage or replace the pitot tube (calibrating the new assembly, if necessary). If the intercomponent spacings have changed, restore the original spacings or recalibrate the assembly.

Documentation: **7-GN-56.**

Response: **Not applicable.**

4.2 Standard pitot tube (if applicable). If a standard pitot tube is used for the velocity traverse, the tube shall be constructed according to the criteria of Section 2.7 and shall be assigned a baseline coefficient value of 0.99. If the standard pitot tube is used as part of the assembly, the tube shall be in an interference-free arrangement (subject to the approval of the Administrator).

Documentation: **7-GN-56, manufacturer's product literature.**

Response: **The standard pitot tube used for velocity traverses meets the criteria of Section 2.7. It is used in conjunction with a digital micromanometer. The internal program of the micromanometer uses unity as the baseline coefficient. This introduces minimal error in the determination of velocity.**

4.3 Temperature Gauges. After each field use, calibrate dial thermometers, liquid-filled bulb thermometers, thermocouple-potentiometer systems, and other gauges at a temperature within 10 percent of the average absolute stack temperature. For temperatures up to 405° C (761° F) use an ASTM mercury-in-glass reference thermometer, or equivalent, as a reference; alternatively, either a reference thermocouple and potentiometer (calibrated by NBS) or thermometric fixed points, e.g., ice bath and boiling water (corrected for barometric pressure) may be used. For temperatures above 405° C (761° F), use an NBS-calibrated reference thermocouple-potentiometer system or an alternate reference, subject to the approval of the Administrator.

If, during calibration, the absolute temperatures measured with the gauge being calibrated and the reference gauge agree within 1.5 percent, the temperature data taken in the field shall be considered valid. Otherwise, the pollutant emission test shall either be considered invalid or adjustments (if appropriate) of the test results shall be made, subject to the approval of the Administrator.

Documentation: **7-GN-56.**

Response: **No temperature measuring devices are used.**

4.4 Barometer. Calibrate the barometer used against a mercury barometer.

Documentation: **7-GN-56.**

Response: **No barometric pressure measuring devices are used.**

5.0 Calculations

Carry out calculations, retaining at least one extra decimal figure beyond that of the acquired data. Round off figures after final calculation.

5.1 Nomenclature. See 40 CFR Pt. 60 App. A, Meth. 2, page 657 and 658 for details).

Documentation: **7-GN-56, manufacturer's product literature.**

Response: **The density program internal to the digital micromanometer is used to determine stack gas velocities which are recorded on data sheets and averaged. The volumetric flow rate is determined from the average flow velocity and sampling duct cross-sectional area.**

40 CFR 60, APPENDIX A, REFERENCE METHOD 1, SAMPLE AND VELOCITY TRAVERSES FOR STATIONARY SOURCES

1.0 Principle and Applicability

1.1 Principle. To aid in the representative measurement of pollutant emissions and/or total volumetric flow rate from a stationary source, a measurement site where the effluent stream is flowing in a known direction is selected, and the cross-section of the stack is divided into a number of equal areas. A traverse point is then located within each of these equal areas.

1.2 Applicability. This method is applicable to flowing gas streams in ducts, stacks, and flues. The method cannot be used when: (1) flow is cyclonic or swirling (see Section 2.4); (2) a stack is smaller than about 0.30 meter (12 in.) in diameter, or 0.071 m2 (113 in.2) cross-sectional area; or (3) the measurement site is less than two stack or duct diameters downstream or less than a half diameter upstream from a flow disturbance.

The requirements of this method must be considered before construction of a new facility from which emissions will be measured; failure to do so may require subsequent alterations to the stack or deviation from the standard procedure. Cases involving variants are subject to approval by the Administrator, U.S. Environmental Protection Agency.

Documentation: Drawings H-2-93415, *291-T-1 Stack Monitor Installation* and BPF-70174, *Concrete Stacks, The Rust Engineering Company* (WHC 1992a; Rust 1992).

Explanatory Remarks: The stack is constructed of reinforced concrete and has an acid-proof brick lining. The stack is 200 ft high with an inside base diameter of 7 ft. The stack tapers to an inside diameter of 5 ft at the top. The sample site is located at the 50-ft level of the stack. The sample site is located 40 ft downstream (or 6.6 average duct diameters) from the last disturbance and 150 ft (or 25 average duct diameters) from the point of release.

2.0 Procedure

2.1 Selection of Measurement Site. Sampling or velocity measurement is performed at a site located at least eight stack or duct diameters downstream and two diameters upstream from any flow disturbance such as a bend, expansion, or contraction in the stack, or from a visible flame. If necessary, an alternative location may be selected, at a position at least two stack or duct diameters downstream and a half diameter upstream from any flow disturbance. For a rectangular cross section, an equivalent diameter (De) shall be calculated from the following equation to determine the upstream and downstream distances:

$$D_e = \frac{2LW}{L+W}$$

L+W where L = length W = width.

An alternative procedure is available for determining the acceptability of a measurement location not meeting the criteria above. This procedure, determination of gas flow angles at the sampling points and comparing the results with acceptability criteria, is described in Section 2.5.

Documentation: Drawings H-2-93415, *291-T-1 Stack Monitor Installation* and BPF-70174, *Concrete Stacks, The Rust Engineering Company.*

Explanatory Remarks: The stack is 200 ft high with an inside base diameter of 7 ft. The stack tapers to an inside diameter of 5 ft

at the top. The sample site is located at the 50-ft level of the stack. The sample site is located 40 ft downstream (or 6.6 average duct diameters) from the last disturbance and 150 ft (or 25 average duct diameters) from the point of release.

2.2 Determining the Number of Traverse Points.

2.2.1 Particulate traverses. When the eight- and two-diameter criterion can be met, the minimum number of traverse points shall be: (1) twelve, for circular or rectangular stacks with diameters (or equivalent diameters) greater than 0.61 meter (24 in.); (2) eight, for circular stacks with diameters between 0.30 and 0.61 meter (12-24 in.); (3) nine, for rectangular stacks with equivalent diameters between 0.30 and 0.61 meter (12-24 in.).

When the eight- and two-diameter criterion cannot be met, the minimum number of traverse points is determined from Figure 1-1. Before referring to the figure, however, determine the distances from the chosen measurement site to the nearest upstream and downstream disturbances, and divide each distance by the stack diameter or equivalent diameter, to determine the distance in terms of the number of duct diameters. Then, determine from Figure 1-1 the minimum number of traverse points that corresponds: (1) to the number of duct diameters upstream; and (2) to the number of diameters downstream. Select the higher of the two minimum numbers of traverse points, or a greater value, so that for circular stacks the number is a multiple of 4, and for rectangular stacks, the number is one of those shown in Table 1-1.

2.2.2 Velocity (Non-Particulate) Traverses. When velocity or volumetric flow rate is to be determined (but not particulate matter), the same procedure as that for particulate traverses (Section 2.2.1) is followed, except that Figure 1-2 may be used instead of Figure 1-1.

2.3 Cross-sectional Layout and Location of Traverse Points.

2.3.1 Circular Stacks. Locate the traverse points on two perpendicular diameters according to Table 1-2 and the example shown on Figure 1-3. Any equation (for examples, see Citations 2 and 3 in the Bibliography) that gives the same values as those in Table 1-2 may be used in lieu of Table 1-2.

For particulate traverses, one of the diameters must be in a plane containing the greatest expected concentration variation, e.g., after bends, one diameter shall be in the plane of the bend. This requirement becomes less critical as the distance from the disturbance increases; therefore, other diameter locations may be used, subject to approval of the Administrator.

In addition for stacks having diameters greater than 0.61 m (24 in.) no traverse points shall be located within 2.5 centimeters (1.00 in.) of the stack walls; and for stack diameters equal to or less than 0.61 m (24 in.), no traverse points shall be located within 1.3 cm (0.50 in.) of the stack walls. To meet these criteria, observe the procedures given below.

2.3.1.1 Stacks With Diameters Greater Than 0.61 m (24 in.). When any of the traverse points as located in Section 2.3.1 fall within 2.5 cm (1.00 in.) of the stack walls, relocate them away from the stack walls to: (1) a distance of 2.5 cm (1.00 in.); or (2) a distance equal to the nozzle inside diameter, whichever is larger. These relocated traverse points (on each end of a diameter) shall be the "adjusted" traverse points.

Whenever two successive traverse points are combined to form a single adjusted traverse point, treat the adjusted point as two separate traverse points, both in the sampling (or velocity measurement) procedure, and in recording the data.

2.3.1.2 Stacks With Diameters Equal to or Less Than 0.61 m (24 in.). Follow the procedure in Section 2.3.1.1, noting only that any "adjusted" points should be relocated away from the stack walls to: (1) a distance of 1.3 cm (0.50 in.); or (2) a distance equal to the nozzle inside diameter, whichever is larger.

2.3.2 Rectangular Stacks. Determine the number of traverse points as explained in Sections 2.1 and 2.2 of this method. From Table 1-1, determine the grid configuration. Divide the stack cross-section into as many equal rectangular elemental areas as traverse points, and then locate a traverse point at the centroid of each equal area according to the example in Figure 1-4.

If the tester desires to use more than the minimum number of traverse points, expand the "minimum number of traverse points" matrix (see Table 1-1) by adding the extra traverse points along one or the other or both legs of the matrix; the final matrix need not be balanced. For example, if a 4x3 "minimum number of points" matrix were expanded to 36 points, the final matrix could be 9x4 or 12x3, and would not necessarily have to be 6x6. After constructing the final matrix, divide the stack cross-section into as many equal rectangular, elemental areas as traverse points, and locate a traverse point at the centroid of each equal area.

The situation of traverse points being too close to the stack walls is not expected to arise with rectangular stacks. If this problem should ever arise, the Administrator must be contacted for resolution of the matter.

2.4 Verification of Absence of Cyclonic Flow. In most stationary sources, the direction of stack gas flow is essentially parallel to the stack walls. However, cyclonic flow may exist (1) after such devices as cyclones and inertial demisters following venturi scrubbers, or (2) in stacks having tangential inlets or other duct configurations which tend to induce swirling; in these instances, the presence or absence of cyclonic flow at the sampling location must be determined. The following techniques are acceptable for this determination.

Level and zero the manometer. Connect a Type S pitot tube to the manometer. Position the Type S pitot tube at each traverse point, in succession, so that the planes of the face openings of the pitot tube are perpendicular to the stack cross-sectional plane; when the Type S pitot tube is in this position, it is at "0° reference." Note the differential pressure (ΔP) reading at each traverse point. If a null (zero) pitot reading is obtained at 0° reference at a given traverse point, an acceptable flow condition exists at that point. If the pitot reading is not zero at 0° reference, rotate the pitot tube (up to ± 90° yaw angle), until a null reading is obtained. Carefully determine and record the value of the rotation angle (α) to the nearest degree. After the null technique has been applied at each traverse point, calculate the average of the absolute values of α; assign α values of 0° to those points for which no rotation was required, and include these in the overall average. If the average value of α is greater than 20°, the overall flow condition in the stack is unacceptable and alternative methodology, subject to the approval of the Administrator, must be used to perform accurate sample and velocity traverses.

The alternative procedure described in Section 2.5 may be used to determine the rotation angles in lieu of the procedure described above.

2.5 Alternative Measurement Site Selection Procedure. This alternative applies to sources where measurement locations are less than 2 equivalent stack or duct diameters downstream or less than 1/2 duct diameter upstream from a flow disturbance. The alternative should be limited to ducts larger than 24 in. in diameter where blockage and wall effects are minimal. A directional flow sensing probe is used to measure pitch and yaw angles of the gas flow at 40 or more traverse points; the resultant angle is calculated and compared with acceptable criteria for mean and standard deviation.

NOTE: Both the pitch and yaw angles are measured from a line passing through the traverse point and parallel to the stack axis. The pitch angle is the angle of the gas flow component in the plane that INCLUDES the traverse line and is parallel to the stack axis. The yaw angle is the angle of the gas flow component in the plane PERPENDICULAR to the traverse line at the traverse point and is measured from the line passing through the traverse point and parallel to the stack axis.

2.5.1 Apparatus.

2.5.1.1 Directional Probe. Any directional probe, such as United Sensor Type DA Three-Dimensional Directional Probe, capable of measuring both the pitch and yaw angles of gas flows is acceptable. (NOTE: Mention of trade name or specific products does not constitute endorsement by the U.S. Environmental Protection Agency.) Assign an identification number to the directional probe, and permanently mark or engrave the number on the body of the probe. The pressure holes or directional probes are susceptible to plugging when used in particulate-laden gas streams. Therefore, a system for cleaning the pressure holes by "backpurging" with pressurized air is required.

2.5.1.2 Differential Pressure Gauges. Inclined manometers, U-tube manometers, or other differential pressure gauges (e.g., magnehelic gauges) that meet the specifications described in Method 2, section 2.2.

NOTE: If the differential pressure gauge produces both negative and positive readings, then both negative and positive pressure readings shall be calibrated at a minimum of three points as specified in Method 2, section 2.2.

2.5.2 Traverse Points. Use a minimum of 40 traverse points for circular ducts and 42 points for rectangular ducts for the gas flow angle determinations. Follow section 2.3 and Table 1-1 or 1-2 for the location and layout of the traverse points. If the measurement location is determined to be acceptable according to the criteria in this alternative procedure, use the same traverse point number and locations for sampling and velocity measurements.

2.5.3 Measurement Procedure.

2.5.3.1 Prepare the directional probe and differential pressure gauges as recommended by the manufacturer. Capillary tubing or surge tanks may be used to dampen pressure fluctuations. It is recommended, but not required, that a pretest leak check be conducted. To perform a leak check, pressurize or use suction on the impact opening until a reading of at least 7.6 cm (3 in.) H_2O registers on the differential pressure gauge, then plug the impact opening. The pressure of a leak-free system will remain stable for at least 15 seconds.

2.5.3.2 Level and zero the manometers. Since the manometer level and zero may drift because of vibrations and temperature changes, periodically check the level and zero during the traverse.

2.5.3.3 Position the probe at the appropriate locations in the gas stream, and rotate until zero deflection is indicated for the yaw angle pressure gauge. Determine and record the yaw angle. Record the pressure gauge readings for the pitch angle, and determine the pitch angle from the calibration curve. Repeat this procedure for each traverse point. Complete a "back-purge" of the pressure lines and the impact openings prior to measurements of each traverse point.

A post-test check as described in section 2.5.3.1 is required. If the criteria for a leak-free system are not met, repair the equipment, and repeat the flow angle measurements.

2.5.4 Calculate the resultant angle at each traverse point, the average resultant angle, and the standard deviation using the following equations. Complete the calculation retaining at least one extra significant figure beyond that of the acquired data. Round the values after the final calculations.

2.5.4.1 Calculate the resultant angle at each traverse point:

2.5.5 The measurement location is acceptable if $R \leq 20°$ and $Sd \leq 10°$.

2.5.6 Calibration. Use a flow system as described in Sections 4.1.2.1 and 4.1.2.2 of Method 2. In addition, the flow system shall have the capacity to generate two test-section velocities: one between 365 and 730 m/min (1200 and 2400 ft/min) and one between 730 and 1100 m/min (2400 and 3610 ft/min).

2.5.6.1 Cut two entry ports in the test section. The axes through the entry ports shall be perpendicular to each other and intersect in the centroid of the test section. The ports should be elongated slots parallel to the axis of the test section and of sufficient length to allow measurement of pitch angles while maintaining the pitot head position at the test-section centroid. To facilitate alignment of the directional probe during calibration, the test section should be constructed of plexiglass or some other transparent material. All calibration measurement should be made at the same point in the test section, preferably at the centroid of the test-section.

2.5.6.2 To ensure that the gas flow is parallel to the central axis of the test section, follow the procedure in Section 2.4 for cyclonic flow determination to measure the gas flow angles at the centroid of the test section from two test ports located 90° apart. The gas flow angle measured in each port must be ± 2° of 0°. Straightening vanes should be installed, if necessary, to meet this criterion.

2.5.6.3 Pitch Angle Calibration. Performs a calibration traverse according to the manufacturer's recommended protocol in 5° increments for angles from -60° to +60° at one velocity in each of the two ranges specified above. Average the pressure ratio values obtained for each angle in the two flow ranges, and plot a calibration curve with the average values of the pressure ratio (or other suitable measurement factor as recommended by the

manufacturer) versus the pitch angle. Draw a smooth line through the data points. Plot also the data values for each traverse point. Determine the differences between the measured data values and the angle from the calibration curve at the same pressure ratio. The difference at each comparison must be within 2° for angles between 0° and 40° and within 3° for angles between 40° and 60°.

2.5.6.4 Yaw Angle Calibration. Mark the three-dimensional probe to allow the determination of the yaw position of the probe. This is usually a line extending the length of the probe and aligned with the impact opening. To determine the accuracy of measurements of the yaw angle, only the zero or null position need be calibrated as follows. Place the directional probe in the test section, and rotate the probe until the zero position is found. With a protractor or other angle measuring device, measure the angle indicated by the yaw angle indicator on the three-dimensional probe. This should be within 2° of 0°. Repeat this measurement for any other points along the length of the pitot where yaw angle measurements could be read in order to account for variations in the pitot markings used to indicate pitot head positions.

ANSI N13.1-1969, GUIDE TO SAMPLING AIRBORNE RADIOACTIVE MATERIALS IN NUCLEAR FACILITIES 4.2.1.2

ANSI N13.1-1969, Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities

4.2.1.2 Sampling point should be a minimum of five diameters (or 5 times the major dimension for rectangular ducts) downstream from abrupt changes in flow direction or prominent transitions.

Documentation: **Drawings H-2-93415,** *291-T-1 Stack Monitor Installation* **and BPF-70174,** *Concrete Stacks, The Rust Engineering Company.*

Explanatory Remarks: **The stack is 200 ft high with an inside base diameter of 7 ft. The stack tapers to an inside diameter of 5 ft at the top. The sample site is located at the 50-ft level of the stack. The sample site is located 40 ft downstream (or 6.6 average duct diameters) from the last disturbance.**

4.2.2 Samples should be representative with respect to physical and chemical composition of airstream.

Documentation: **Drawings H-2-93415,** *291-T-1 Stack Monitor Installation*; **BPF-70174,** *Concrete Stacks, The Rust Engineering Company*, **and H-2-92499,** *Generic Stack Alpha, Beta, Record, Cabinet Assembly.*

Explanatory Remarks: **The stack and the sampling system operate at ambient temperatures. Isokinetic samples of radioactive particles are taken.**

4.3.1 Sensitivity and accuracy of the analytical or counting method will determine the minimum volume of air which must be sampled to obtain the requisite accuracy and precision of results.

4.3.2 If possible, the sample should be large enough to permit 1/10 the permissible level to be determined with reliability.

The record sample filter is exchanged every 168 hours (WHC-IP-0692) to ensure a sufficient loading for laboratory analysis (WHC 1991b). A discussion of laboratory analysis methods is found in WHC-EP-0536 (WHC 1991c).

5.2.2 Airborne particulate matter should be evaluated and characterized at regular intervals and before any anticipated process change.

Documentation: **WHC-IP-0692 and Scheduled Radiation Survey Task Description (WHC 1991b).**

Explanatory Remarks: **The samplers operate continuously. Samples are captured on a particulate filter. Samples are collected weekly, in accordance with the referenced procedures.**

5.2.2.1 Appropriate filtration should be chosen for sampling.

Documentation: **WHC-IP-0692 and Gelman Science Inc. (WHC 1991b).**

Explanatory Remarks: The Gelman Versapor 3000 filter medium is an acrylic copolymer membrane supported by a non-woven nylon fabric. The manufacturer rates the efficiency of this medium at 91% for 0.3-μm aerosol. The manufacturer recently tested 24 samples with a 0.3-μm di-octyl phthalate (DOP) aerosol per ASTM D 2986-71. The measured average efficiency was 95.8%, and the standard deviation was 1.6%, which supports the rated efficiency.

5.2.2.1.7 Filter holders and support should be chosen for proper chemical compatibility, mechanical strength, sealing, and ease of operation in changing filters. Sample air movers should have the capability of delivering the necessary air flow against the resistance of the sampling system.

Proper location and choice of flow measurement device and flow rate control is important.

Documentation: WHC-IP-0692, "Operation of Gaseous Effluent Sampling and Monitoring System and Occupational Health and Safety - Scheduled Radiation Survey Task Description" and Drawing H-2-92499, *Generic Stack Alpha, Beta, Record, Cabinet Assembly* (WHC 1991b).

Explanatory Remarks: The facility uses aluminum sample holders with a rubber "O" ring seal. Aluminum is considered very corrosion resistant to moist or ambient air. The sample holders are easily opened by unscrewing the ends.

The facility has a dedicated vacuum pump for pulling stack samples. The sample flow passes through a flow meter, a flow totalizer, and a flow regulator, all of which are located downstream from the particulate sampler. The visual float on the flow meter is verified weekly during sample collection in accordance with the referenced procedures.

5.3 Airborne radioactive gases or volatile materials should be sampled by an appropriate method if present.

Documentation: WHC-IP-0692 (WHC 1991b).

Explanatory Remarks: T Plant gets their radioactivity from equipment brought in for decontamination or certification. The presence or absence of radioactive gasses is not documented.

A1. Minimization of the length and bends of sample delivery lines will contribute to representative sampling.

Documentation: Drawing H-2-93415, *291-T-1 Stack Monitor Installation.*

Explanatory Remarks: The sample delivery line is runs approximately 50 ft vertical. The line has one 90° bend. The sample cabinet is currently being moved for improved safety. The new location will result in the 90° being broken into two more gradual bends and shorten the sample line by 0.5 ft.

A2. Selection of sampling position along a stack.

Documentation: Drawings H-2-93415, *291-T-1 Stack Monitor Installation* and BPF-70174, *Concrete Stacks*, *The Rust Engineering Company*.

Explanatory Remarks: The stack is 200 ft high with an inside base diameter of 7 ft. The stack tapers to an inside diameter of 5 ft at the top. The sample site is located at the 50 ft level of the stack. The sample site is located 40 ft downstream (or 6.6 average duct diameters) from the last disturbance and 150 ft (or 25 average duct diameters) from the point of release. The sample delivery line runs approximately 50 ft vertical.

A3.1 Velocity and flow distribution should be known for the sampling point, and particle and gaseous composition should be representative.

Documentation: Drawings H-2-93414, *Stack Monitor Probe Assembly 291-T-1*, and BPF-70174, *Concrete Stacks*, *The Rust Engineering Company* (WHC 1992a; Rust 1992).

Explanatory Remarks: Although a velocity distribution is not known, the flow can be shown to be turbulent.

The stack has an average diameter of 6 ft and the stack flow velocity is 808.7 ft/min, as shown on the referenced drawing. Given this and the information provided in ANSI N13.1-1969, it can be proven that the Reynolds number (Re) exceeds 2100, the point at which flow is assumed to be turbulent.

$$Re = \frac{(\text{dia.})(\text{velocity})(\text{density})}{\text{viscosity}}$$

$$Re = 5E5 = \frac{(183\ \text{cm})(410.8\ \text{cm/s})(0.0012\ \text{g/cm}^3)}{(0.00018\ \text{g/cm-s})}$$

As stated in the ANSI Standard, Section A3.3.2, "as the flow becomes more turbulent, the velocity becomes more nearly uniform across the duct."

A3.2 A multiple number of withdrawal points each representing approximately equal areas based on the duct or stack dimensions is desirable.

Documentation: Drawing H-2-93414, *Stack Monitor Probe Assembly 291-T-1*.

Explanatory Remarks: The sampler uses a single sample probe with 10 sample nozzles. The inside diameter of each nozzle is 0.37 in. Each nozzle covers 3.3 ft^2 of area.

A3.3 The velocity distribution across the duct or stack should be known in order to establish isokinetic flow and representative sample points.

Documentation: Drawings H-2-93414, *Stack Monitor Probe Assembly 291-T-1* and BPF-70174, *Concrete Stacks*, *The Rust Engineering Company*.

Explanatory Remarks: Although a velocity distribution is not known, the flow can be shown to be turbulent.

The stack has an average diameter of 6 ft and the stack flow velocity is 808.7 ft/min, as shown on the referenced drawing. Given this and the information provided in ANSI N13.1-1969, it can be proven that the Re exceeds 2100, the point at which flow is assumed to be turbulent.

$$Re = \frac{(dia.)(velocity)(density)}{viscosity}$$

$$Re = 5E5 = \frac{(183\ cm)(410.8\ cm/s)(0.0012\ g/cm^3)}{(0.00018\ g/cm\text{-}sec)}$$

As stated in the ANSI Standard, Section A3.3.2, "as the flow becomes more turbulent, the velocity becomes more nearly uniform across the duct." Based on this, the sampling probe is assumed to be isokinetic.

A3.4 Sampling probe configuration is recommended by figures in this standard, with minimum radius bends and precisely tapered probe end edges.

Documentation: Drawing H-2-93414, *Stack Monitor Probe Assembly 291-T-1.*

Explanatory Remarks: The sampler uses a single probe with 10 sample nozzles. The inside diameter (D) of the nozzles is 0.37 in. The radius (R) of the nozzle bend is 1.5 in. (R=4D). The length from the inlet to the bend is 0.5 in. (L=1.3D).

B1. Sampling line length should be kept to a minimum length. An estimate of the fraction of particles deposited in sampling lines under various conditions should be made using the experimental data presented in this appendix.

Documentation: Drawing H-2-93415, *291-T-1 Stack Monitor Installation.*

Explanatory Remarks: The sample delivery line runs approximately 50 ft vertical. The line has one 90° bend. The sample cabinet is currently being moved for improved safety. The new location will result in the 90° being broken into two more gradual bends and shorten the sample line 0.5 ft.

B3. Velocities must be kept high enough to avoid appreciable losses by Brownian diffusion.

Documentation: Drawing H-2-93414, *Stack Monitor Probe Assembly 291-T-1*

Explanatory Remarks: The sample is drawn through the probe and the sample line at 6.2 ft^3/min.

B5. Elbows in sampling lines should be avoided if at all possible. When required, the bend radius of the elbow should be as long as practical, and design flow rates through any line containing an elbow should be kept low. When possible, the sampler installation should allow for probe removal in order to evaluate the losses in the probe entry elbow and to permit cleaning.

Documentation: **Drawing H-2-93415,** *291-T-1 Stack Monitor Installation.*

Explanatory Remarks: **The sample delivery line is run approximately 50 ft vertical. The line has one 90° bend. The sample cabinet is currently being moved for improved safety. The new location will result in the 90° being broken into two more gradual bends and shorten the sample line 0.5 ft.**

METHOD 114 COMPARISON FOR STACK 291-T-1

1.0 Purpose and Background

This method provides the requirements for: (1) Stack monitoring and sample collection methods appropriate for radionuclides; (2) radiochemical methods which are used in determining the amounts of radionuclides collected by the stack sampling and; (3) quality assurance methods which are conducted in conjunction with these measurements. These methods are appropriate for emissions for stationary sources. A list of references is provided.

Many different types of facilities release radionuclides into air. These radionuclides differ in the chemical and physical forms, half-lives and type of radiation emitted. The appropriate combination of sample extraction, collection and analysis for an individual radionuclide is dependent upon many interrelated factors including the mixture of other radionuclides present. Because of this wide range of conditions, no single method for monitoring or sample collection and analysis of a radionuclide is applicable to all types of facilities. Therefore, a series of methods based on "principles of measurement" are described for monitoring and sample collection and analysis which are applicable to the measurement of radionuclides found in effluent streams at stationary sources. This approach provides the user with the flexibility to choose the most appropriate combination of monitoring and sample collection and analysis methods which are applicable to the effluent stream to be measured.

Response: **Our answers to EPA requirements (regulatory criteria 40 CFR 61, Subpart H, Appendix B, Method 114) (EPA 1991) regarding Hanford Site air emissions are provided here.**

2.0 Stack Monitoring and Sample Collection Methods

Monitoring and sample collection methods are described based on "principles of monitoring and sample collection" which are applicable to the measurement of radionuclides from effluent streams at stationary sources. Radionuclides of most elements will be in the particulate form in these effluent streams and can be readily collected using a suitable filter media. Radionuclides of hydrogen, oxygen, carbon, nitrogen,the noble gases and in some circumstances iodine will be in the gaseous form. Radionuclides of these elements will require either the use of an in-line or off-line monitor to directly measure the radionuclides, or suitable sorbers, condensers or bubblers to collect the radionuclides.

2.1 Radionuclides as Particulates. The extracted effluent stream is passed through a filter media to remove the particulates. The filter must have a high efficiency for removal of sub-micron particles. The guidance in ANSI N13.1-1969 shall be followed in using filter media to collect particulates (incorporated by reference-see § 61.18).

The facility uses WHC-IP-0692, "Operation of Gaseous Effluent Sampling and Monitoring System" for direction in choosing filter media (WHC 1991b). The Gelman Versapor 3000 filter medium is an acrylic copolymer membrane supported by a non-woven nylon fabric. The manufacturer rates the efficiency of this medium at 91% for 0.3-μm aerosol. The manufacturer recently tested 24 samples with a 0.3-μm DOP aerosol per ASTM D 2986-71. The measured average efficiency was 95.8%, and the standard deviation was 1.6%, which supports the rated efficiency.

2.2 Radionuclides as Gases.

2.2.1 The Radionuclide Tritium (H-3). Tritium in the form of water vapor is collected from the extracted effluent sample by sorption, condensation or dissolution techniques. Appropriate collectors may include silica gel, molecular sieves, and ethylene glycol or water bubblers.

Tritium in the gaseous form may be measured directly in the sample stream using Method B-1, collected as a gas sample or may be oxidized using a metal catalyst to tritiated water and collected as described above.

T Plant gets their radioactivity from equipment brought in for decontamination or certification. The presence of

radioactive gasses is not known. To date, T Plant has not evaluated the need to implement monitoring of tritium in the stack effluent.

2.2.2 Radionuclides of iodine. Iodine is collected from an extracted sample by sorption or dissolution techniques. Appropriate collectors may include charcoal, impregnated charcoal, metal zeolite and caustic solutions.

T Plant gets their radioactivity from equipment brought in for decontamination or certification. The presence of radioactive gasses is not known. To date, T Plant has not evaluated the need to implement monitoring of radioactive iodine in the stack effluent.

2.2.3 Radionuclides of Argon, Krypton and Xenon. Radionuclides of these elements are either measured directly by an in-line or off-line monitor, or are collected from the extracted sample by low temperature sorption techniques, Appropriate sorbers may include charcoal or metal zeolite.

T Plant gets their radioactivity from equipment brought in for decontamination or certification. The presence of radioactive gasses is not known. To date, T Plant has not evaluated the need to implement monitoring of argon, krypton, or xenon in the stack effluent.

2.2.4 Radionuclides of Oxygen, Carbon, Nitrogen and Radon. Radionuclides of these elements are measured directly using an in-line or off-line monitor. Radionuclides of carbon in the form of carbon dioxide may be collected by dissolution in caustic solutions.

T Plant gets their radioactivity from equipment brought in for decontamination or certification. The presence of radioactive gasses is not known. To date, T Plant has not evaluated the need to implemented monitoring of oxygen, carbon, nitrogen, or radon in the stack effluent.

2.3 Definition of Terms

In-line monitor means a continuous measurement system in which the detector is placed directly in or adjacent to the effluent stream. This may involve either gross radioactivity measurements or specific radionuclide measurements. Gross measurements shall be made in conformance with the conditions specified in Methods A-4, B-2 and G-4.

Off-line monitor means a measurement system in which the detector is used to continuously measure an extracted sample of the effluent stream. This may involve either gross radioactivity measurements or specific radionuclide measurements. Gross measurements shall be made in conformance with the conditions specified in Methods A-4, B-2 and G-4.

Sample collection means a procedure in which the radionuclides are removed from an extracted sample of the effluent using a collection media. These collection media include filters, absorbers, bubblers and condensers. The collected sample is analyzed using the methods described in Section 3.

3.0 Radionuclide Analysis Methods

A series of methods based on "principles of measurement" are described which are applicable to the analysis of radionuclides collected from airborne effluent streams at stationary sources. These methods are applicable only under the conditions stated and within the limitations described. Some methods specify that only a single radionuclide be present in the sample or the chemically separated sample. This condition should be interpreted to mean that no other radionuclides are present in quantities which would interfere with the measurement.

Also identified (Table 1) are methods for a selected list of radionuclides. The listed radionuclides are those which are most commonly used and which have the greatest potential for causing dose to members of the public. Use of methods based on principles of measurement other than those described in this section must be approved in advance of use by the Administrator. For radionuclides not

listed in Table 1, any of the described methods may be used provided the user can demonstrate that the applicability conditions of the method have been met.

The type of method applicable to the analysis of a radionuclide is dependent upon the type of radiation emitted, i.e., alpha, beta or gamma. Therefore, the methods described below are grouped according to principles of measurements for the analysis of alpha, beta and gamma emitting radionuclides.

3.1.1 Method A-1, Radiochemistry-Alpha Spectrometry.

Principle: The element of interest is separated from other elements, and from the sample matrix using radiochemical techniques. The procedure may involve precipitation, ion exchange, or solvent extraction. Carriers (elements chemically similar to the element of interest) may be used. The element is deposited on a planchet in a very thin film by electrodeposition or by coprecipitation on a very small amount of carrier, such as lanthanum fluoride. The deposited element is then counted with an alpha spectrometer. The activity of the nuclide of interest is measured by the number of alpha counts in the appropriate energy region. A correction for chemical yield and counting efficiency is made using a standardized radioactive nuclide (tracer) of the same element. If a radioactive tracer is not available for the element of interest, a predetermined chemical yield factor may be used.

Applicability: This method is applicable for determining the activity of any alpha-emitting radionuclide, regardless of what other radionuclides are present in the sample provided the chemical separation step produces a very thin sample and removes all other radionuclides which could interfere in the spectral region of interest. APHA-605(2), ASTM-D-3972(13).

Response: **Our method involves dissolution (LA-549-112), chemical separation (LA-943-123), electrodeposition (LA-542-101), followed by alpha spectrometry (LA-508-051). It meets all the requirements of the EPA-suggested method. This is used for analyzing ^{241}Am, ^{238}Pu, and ^{239,240}Pu in the air filter samples. The activities of these radionuclides are determined by direct comparison with the recoveries of (National Institute of Standards and Technology ([NIST] traceable) ^{243}Am and ^{236}Pu tracers (WHC 1992c).**

3.1.2 Method A-2, Radiochemistry-Alpha Counting.

Principle: The element of interest is separated from other elements, and from the sample matrix using radiochemistry. The procedure may involve precipitation, ion exchange, or solvent extraction. Carriers (elements chemically similar to the element of interest) may be used. The element is deposited on a planchet in a thin film and counted with a alpha counter. A correction for chemical yield (if necessary) is made. The alpha count rate measures the total activity of all emitting radionuclides of the separated element.

Applicability: This method is applicable for the measurement of any alpha-emitting radionuclide, provided no other alpha emitting radionuclide is present in the separated sample. It may also be applicable for determining compliance, when other radionuclides of the separated element are present, provided that the calculated emission rate is assigned to the radionuclide which could be present in the sample that has the highest dose conversion factor. IDO-12096(18).

Response: **Because the tracer technique is used in the separation process, this method is not used for air filter analysis.**

3.1.3 Method A-3, Direct Alpha Spectrometry.

Principle: The sample, collected on a suitable filter, is counted directly on an alpha spectrometer. The sample must be thin enough and collected on the surface of the filter so that any absorption of alpha particle energy in the sample or the filter, which would degrade the spectrum, is minimal.

Applicability: This method is applicable to simple mixtures of alpha emitting radionuclides and only when the amount of particulates collected on the filter paper are relatively small and the alpha spectra is adequately resolved. Resolutions should be 50 keV (FWHM) or better, ASTM-D-3084(16).

Response: **Our method follows the procedure LO-150-133, then LA-508-110 for total alpha counts, and finally LA-508-051 for alpha spectrometry. It partially meets the requirements of the EPA method. This method is usually used for emergency air samples. The sample is counted on the alpha counter of known efficiency to obtain the total alpha counts. In the alpha energy analysis (AEA), the relative peak fractions of different alpha emitters identified in the sample are determined. The peak fractions are then used to correct the total alpha counts and thus determine the activities of individual alpha radionuclides present in the sample (WHC 1992c).**

3.1.4 Method A-4, Direct Alpha Counting (Gross alpha determination).

Principle: The sample, collected on a suitable filter, is counted with an alpha counter. The sample must be thin enough so that self-absorption is not significant and the filter must be of such a nature that the particles are retained on the surface.

Applicability: Gross alpha determination may be used to measure emissions of specific radionuclides only (1) when it is known that the sample contains only a single radionuclide, or the identity and isotopic ratio of the radionuclides in the sample are well known, and (2) measurements using either Method A-1, A-2 or A-5 have shown that this method provides a reasonably accurate measurement of the emission rate. Gross alpha measurements are applicable to unidentified mixtures of radionuclides only for the purposes and under the conditions described in section 3.7. APHA-601(3), ASTM-D-1943(10).

Response: Our method follows the procedure LA-508-110 or LA-508-114 (WHC 1992c). It meets all of the requirements stated in the EPA-suggested method.

3.1.5 Method A-5, Chemical Determination of Uranium.

Uranium: Uranium may be measured chemically by either colorimetry or fluorometry. In both procedures, the sample is dissolved, the uranium is oxidized to the hexavalent form and extracted into a suitable solvent. Impurities are removed from the solvent layer. For colorimetry, dibenzoylmethane is added, and the uranium is measured by the absorbance in a colorimeter. For fluorometry, a portion of the solution is fused with a sodium fluoride-lithium fluoride flux and the uranium is determined by the ultraviolet activated fluorescence of the fused disk in a fluorometer.

Applicability: This method is applicable to the measurements of emission rates of uranium when the isotopic ratio of the uranium radionuclides is well known. ASTM-E318(15), ASTM-D-2907(14).

Response: **Total uranium is determined by procedure LA-925-107. The laser-induced kinetic phosphorescence analyzer is an improvement over the old fluorometric method for uranium determination. It is highly sensitive (lower detection level of 50 ppt is quite possible) because the laser frequency is used specifically for excitation of uranium atoms. It is faster and produces quality numbers. Quality can also be monitored during analysis. It exceeds the requirements mentioned in the EPA method.**

3.1.6 Method A-6, Radon-222-Continuous Gas Monitor.

Principle: Radon-222 is measured directly in a continuously extracted sample stream by passing the air stream through a calibrated scintillation cell. Prior to the scintillation cell, the air stream is treated to remove particulates and excess moisture. The alpha particles from radon-222 and its decay products strike a zinc sulfide coating on the inside of the scintillation cell producing light pulses. The light pulses are detected by a photomultiplier tube which generates electrical pulses. These pulses are processed by the system electronics and the read out is in pCi/l of radon-222.

Applicability: This method is applicable to the measurement of radon-222 in effluent streams which do not contain significant quantities of radon-220. Users of this method should calibrate the monitor in a radon calibration chamber at least twice per year. The background of the monitor should also be checked periodically by operating the instrument in a low radon environment. EPA 520/1-89-009(24).

Response: **Not applicable at the 222-S Laboratory.**

3.1.7 Method A-7, Radon-222-Alpha Track Detectors

Principle: Radon-222 is measured directly in the effluent stream using alpha track detectors (ATD). The alpha particles emitted by radon-222 and its decay products strike a small plastic strip and produce submicron damage tracks. The plastic strip is placed in a caustic solution that accentuates the damage tracks which are counted using a microscope or automatic counting system. The number of tracks per unit area is corrected to the radon concentration in air using a conversion factor derived from data generated in a radon calibration facility.

Applicability: Prior approval from EPA is required for use of this method. This method is only applicable to effluent streams which do not contain significant quantities of radon-220, unless special detectors are used to discriminate against radon 220. This method may be used only when ATDs have been demonstrated to produce data comparable to data obtained with Method A-6. Such data should be submitted to EPA when requesting approval for the use of this method. EPA 520/1-89-009(24).

Response: **Not applicable; direct monitoring of ^{222}Rn is not performed at the 222-S Laboratory.**

3.2 Methods for Gaseous Beta Emitting Radionuclides.

3.2.1 Method B-1, Direct Counting in Flow-Through Ionization Chambers.

Principle: An ionization chamber containing a specific volume of gas which flows at a given flow rate through the chamber is used. The sample (effluent stream sample) acts as the counting gas for the chamber. The activity of the radionuclide is determined from the current measured in the ionization chamber.

Applicability: This method is applicable for measuring the activity of a gaseous beta emitting radionuclide in an effluent stream that is suitable as a counting gas, when no other beta-emitting nuclides are present. DOE/EP-0096(17), NCRP-58(23).

Response: **Not applicable; not performed.**

3.2.2 Method B-2, Direct Counting With In-line or Off-line Beta Detectors.

Principle: The beta detector is placed directly in the effluent stream (in-line) or an extracted sample of the effluent stream is passed through a chamber containing a beta detector (off-line). The activities of the radionuclides present in the effluent stream are determined from the beta count rate, and a knowledge of the radionuclides present and the relationship of the gross beta count rate and the specific radionuclide concentration.

Applicability: This method is applicable only to radionuclides with maximum beta particle energies greater then 0.2 MeV. This method may be used to measure emissions of specific radionuclides only when it is known that the sample contains only a single radionuclide or the identity and isotopic ratio of the radionuclides in the effluent stream are well known. Specific radionuclide analysis of periodic grab samples may be used to identify the types and quantities of radionuclides present and to establish the relationship between specific radionuclide analyses and gross beta count rates.

This method is applicable to unidentified mixtures of gaseous radionuclides only for the purposes and under the conditions described in section 3.7.

Response: **Not applicable; not performed.**

3.3 Methods for Non-Gaseous Beta Emitting Radionuclides.

3.3.1 Method B-3, Radiochemistry-Beta Counting.

Principle: The element of interest is separated from other elements, and from the sample matrix by radiochemistry. This may involve precipitation, distillation, ion exchange, or solvent extraction. Carriers (elements chemically similar to the element of interest) may be used. The element is deposited on a planchet, and counted with a beta counter.

Corrections for chemical yield and decay (if necessary) are made. The beta count rate determines the total activity of all radionuclides of the separated element. This method may also involve the radiochemical separation and counting of a daughter element, after a suitable period of ingrowth, in which case it is specific for the parent nuclide.

Applicability: This method is applicable for measuring the activity of any beta-emitting radionuclide, with a maximum energy greater than 0.2 MeV, provided no other radionuclide is present in the separated sample. APHA-608(5).

Response: **Our method for determining ^{89}Sr, $^{90}Sr/^{90}Y$ in air filter samples is carried out using procedures LA-549-112 (dissolution) and LA-220-103 (for chemical separation), followed by procedure LA-508-111 (total beta counting) (WHC 1992c). The laboratory method certainly meets the requirements stated above.**

3.3.2 Method B-4, Direct Beta Counting (Gross beta determination).

Principle: The sample, collected on a suitable filter, is counted with a beta counter. The sample must be thin enough so that self-absorption corrections can be made.

Applicability: Gross beta measurements are applicable only to radionuclides with maximum beta particle energies greater than 0.2 MeV. Gross beta measurements may be used to measure emissions of specific radionuclides only (1) when it is known that the sample contains only a single radionuclide, and (2) measurements made using Method B-3 show reasonable agreement with the gross beta measurement. Gross beta measurements are applicable to mixtures of radionuclides only for the purposes and under the conditions described in section 3.7. APHA-602(4), ASTM-D-1890(11).

Response: **For gross beta determination, procedure LA-508-110 or LA-508-114 is followed (WHC 1992c). It satisfies the method requirements.**

3.3.3 Method B-5, Liquid Scintillation Spectrometry.

Principle: An aliquot of a collected sample or the result of some other chemical separation or processing technique is added to a liquid scintillation "cocktail" which is viewed by photomultiplier tubes in a liquid scintillation spectrometer. The spectrometer is adjusted to establish a channel or "window" for the pulse energy appropriate to the nuclide of interest. The activity of the nuclide of interest is measured by the counting rate in the appropriate energy channel. Corrections are made for chemical yield where separations are made.

Applicability: This method is applicable to any beta-emitting nuclide when no other radionuclide is present in the sample or the separated sample provided that it can be incorporated in the scintillation cocktail. This method is also applicable for samples which contain more than one radionuclide but only when the energies of the beta particles are sufficiently separated so that they can be resolved by the spectrometer. This method is most applicable to the measurement of low-energy beta emitters such as tritium and carbon-14. APHA.609(6), EML LV-539-17(19).

Response: **It is used for determining ^{147}Pm in air filter samples (LA-549-112 for dissolution, LA-613-111 for chemical separation, LA-548-111 for incorporating into scintillation cocktail, and LA-508-121 for liquid scintillation counting). This is also used for determination of ^{14}C (LA-348-101, LA-548-111, and LA-508-121, sequentially) and ^{3}H (LA-218-112, LA-548-111, and LA-508-121, sequentially) in gas samples. This method satisfies all of the requirements.**

3.4 Gamma Emitting Radionuclides

3.4.1 Method G-1. High Resolution Gamma Spectrometry.

Principle: The sample is counted with a high resolution gamma detector, usually either a Ge(Li) or a high purity Ge detector, connected to a multichannel analyzer or computer. The gamma emitting radionuclides in the sample are measured from the gamma count rates in the energy regions characteristic of the individual radionuclide. Corrections are made for counts contributed by other radionuclides to the spectral regions of the radionuclides of

interest. Radiochemical separations may be made prior to counting but are usually not necessary.

Applicability: This method is applicable to the measurement of any gamma emitting radionuclide with gamma energies greater than 20 keV. It can be applied to complex mixtures of radionuclides. The samples counted may be in the form of particulate filters, absorbers, liquids or gases. The method may also be applied to the analysis of gaseous gamma emitting radionuclides directly in an effluent stream by passing the stream through a chamber or cell containing the detector. ASTM-3649(9), IDO-12096(18).

Response: **Our method uses gamma ray spectroscopy with high resolution germanium detectors and follows procedure LA-508-052. It meets all the requirements explained in the EPA method.**

3.4.2 Method G-2, Low Resolution Gamma Spectrometry.

Principle: The sample is counted with a low resolution gamma detector, a thallium activated sodium iodide crystal. The detector is coupled to a photomultiplier tube and connected to a multichannel analyzer. The gamma emitting radionuclides in the sample are measured from the gamma count rates in the energy regions characteristic of the individual radionuclides. Corrections are made for counts contributed by other radionuclides to the spectral regions of the radionuclides of interest. Radiochemical separation may be used prior to counting to obtain less complex gamma spectra if needed.

Applicability: This method is applicable to the measurement of gamma emitting radionuclides with energies greater than 100 keV. It can be applied only to relatively simple mixtures of gamma emitting radionuclides. The samples counted may be in the form of particulate filters, absorbers, liquids or gas. The method can be applied to the analysis of gaseous radionuclides directly in an effluent stream by passing the gas stream through a chamber or cell containing the detector. ASTM-D-2459(12), EMSL-LV-0539-17(19).

Response: **Not applicable because this method is not used in air filter analysis.**

3.4.3 Method G-3, Single Channel Gamma Spectrometry.

Principle: The sample is counted with a thallium activated sodium iodide crystal. The detector is coupled to a photomultiplier tube connected to a single channel analyzer. The activity of a gamma emitting radionuclide is determined from the gamma counts in the energy range for which the counter is set.

Applicability: This method is applicable to the measurement of a single gamma emitting radionuclide. It is not applicable to mixtures of radionuclides. The samples counted may be in the form of particulate filters, absorbers, liquids or gas. The method can be applied to the analysis of gaseous radionuclides directly in an effluent stream by passing the gas stream through a chamber or cell containing the detector.

Response: **Not applicable because this technique is not used in air filter analysis.**

3.4.4 Method G-4, Gross Gamma Counting.

Principle: The sample is counted with a gamma detector usually a thallium activated sodium iodine crystal. The detector is coupled to a photomultiplier tube and gamma rays above a specific threshold energy level are counted.

Applicability: Gross gamma measurements may be used to measure emissions of specific radionuclides only when it is known that the sample contains a single radionuclide or the identity and isotopic ratio of the radionuclides in the effluent stream are well known. When gross gamma measurements are used to determine emissions of specific radionuclides periodic measurements using Methods G-1 or G-2 should be made to demonstrate that the gross gamma measurements provide reliable emission data. This method may be applied to analysis of gaseous radionuclides directly in an effluent stream by placing the detector directly in or adjacent to the effluent stream or passing an extracted sample of the effluent stream through a chamber or cell containing the detector.

Response: **Not applicable.**

3.5 Counting Methods. All of the methods with the exception of Method A-5 involve counting the radiation emitted by the radionuclide. Counting methods applicable to the measurement of

alpha, beta and gamma radiations are listed below. The equipment needed and the counting principles involved are described in detail in ASTM-3648(8).

3.5.1 Alpha Counting:

- Gas Flow Proportional Counters. The alpha particles cause ionization in the counting gas and the resulting electrical pulses are counted. These counters may be windowless or have very thin windows.

- Scintillation Counters. The alpha particles transfer energy to a scintillator resulting in a production of light photons which strike a photomultiplier tube converting the light photons to electrical pulses which are counted. The counters may involve the use of solid scintillation materials such as zinc sulfide or liquid scintillation solutions.

- Solid-State Counters. Semiconductor materials, such as silicon surface-barrier p-n junctions, act as solid ionization chambers. The alpha particles interact which the detector producing electron hole pairs. The charged pair is collected by an applied electrical field and the resulting electrical pulses are counted.

- Alpha Spectrometers. Semiconductor detectors used in conjunction with multichannel analyzers for energy discrimination.

Response: **Alpha proportional counters (home-built chambers with EG&G ORTEC electronics), window-type gas flow proportional counters (some having automatic sample changer), surface-barrier solid-state detectors connected to a multichannel analyzer (MCA) (Series 85, Jupiter system manufactured by Canberra Industries, Inc.) are used for air filter analysis in 222-S Laboratory. Laboratory equipment meets the EPA specifications.**

3.5.2 Beta Counting:

- Ionization Chambers. These chambers contain the beta-emitting nuclide in gaseous form. The ionization current produced is measured.

- Geiger-Muller (GM) Counters-or Gas Flow Proportional Counters. The beta particles cause ionization in the counting gas and the resulting electrical pulses are counted. Proportional gas flow counters which are heavily shielded by lead or other metal, and provided with an anti-coincidence shield to reject cosmic rays, are called low background beta counters.

- Scintillation Counters. The beta particles transfer energy to a scintillator resulting in a production of light photons, which strike a photomultiplier tube converting the light photon to electrical pulses which are counted. This may involve the use of anthracene crystals, plastic scintillator, or liquid scintillation solutions with organic phosphors.

- Liquid Scintillation Spectrometers. Liquid scintillation counters which use two photomultiplier tubes in coincidence to reduce background counts. This counter may also electronically discriminate among pulses of a given range of energy.

Response: **Window-type gas flow proportional counter (some having an automatic sample changer) liquid scintillation spectrometers manufactured by Beckman Instruments, Inc., are used for analysis. Our counting equipment meets the requirements.**

3.5.3 Gamma Counting:

- Low-Resolution Gamma Spectrometers. The gamma rays interact with thallium activated sodium iodide or cesium iodide crystal resulting in the release of light photons which strike a photomultiplier tube converting the light pulses to electrical pulses proportional to the energy of the gamma ray. Multi-channel analyzers are used to separate and store the pulses according to the energy absorbed in the crystal.

- High-Resolution gamma Spectrometers. Gamma rays interact with a lithium-drifted (Ge(Li)) or high-purity germanium (HPGe) semiconductor detectors resulting in a production of electron-hole pairs. The charged pair is collected by an applied electrical field. A very stable low noise preamplifier amplifies the pulses of electrical charge resulting from the gamma photon interactions. Multichannel analyzers or computers are used to separate and store the pulses according to the energy absorbed in the crystal.

- Single Channel Analyzers. Thallium activated sodium iodide crystals used with a single window analyzer. Pulses from the photomultiplier tubes are separated in a single predetermined energy range.

Response: **High-resolution gamma detectors (high-purity Ge detectors for both low and high energies) from EG&G ORTEC and Princeton Gamma Tech, well-type pure Ge detectors connected to MCA (Canberra's Jupiter system) are available and used for air filter analysis. Our equipment exceeds the EPA requirements.**

3.5.4 Calibration of Counters. Counters are calibrated for specific radionuclide measurements using a standard of the radionuclide under either identical or very similar conditions as the sample to be counted. For gamma spectrometers a series of standards covering the energy range of interest may be used to construct a calibration curve relating gamma energy to counting efficiency.

In those cases where a standard is not available for a radionuclide, counters may be calibrated using a standard with energy characteristics as similar as possible to the radionuclide to be measured. For gross alpha and beta measurements of the unidentified mixtures of radionuclides, alpha counters are calibrated with a natural uranium standard and beta counters with a cesium-137 standard. The standard must contain the same weight and distribution of solids as the samples, and be mounted in an identical manner. If the samples contain variable amounts of solids, calibration curves relating weight of solids present to counting efficiency are prepared. Standards other than those prescribed may be used provided it can be shown that such standards are more applicable to the radionuclide mixture measured.

Response: **A mixed gamma standard (NIST traceable) emitting various gamma-rays ranging from 59 to 1850 keV is used, using vendor-supplied calibration software, for constructing efficiency versus energy calibration curves for different geometrical configurations used in gamma analysis. The calibration procedure for gamma ray spectrometer is documented in LQ-508-003. Our calibration procedure meets the EPA criteria for gamma ray spectroscopic analysis.**

For calibration of beta detectors for $^{90}Sr/^{90}Y$ analysis, procedure LQ-508-002 is used in conjunction with LQ-508-005. It meets the requirements of the EPA-suggested method. A method standard also is used to check the performance and calibration of the detector.

For calibration of alpha/beta proportional counters, the procedure LQ-508-002 is carried out. It partially deviates from the EPA requirements. For gross alpha and gross beta measurements, our instruments are calibrated with ^{241}Am and ^{60}Co standards, respectively. The reasons for choosing the ^{241}Am standard for alpha calibration are as follows:

- **It is commonly found in the main stack air samples.**

- Alpha counting efficiency usually is the same for other alpha emitters that also are found in the air stack samples

- The ^{241}Am standard also can be checked independently by gamma analysis.

The reason for using the ^{60}Co standard for beta calibration is the lower counting efficiency with ^{60}Co (beta max = 317 keV) compared to those with ^{137}Cs (beta max = 511 keV) and ^{90}Sr (beta max = 546 keV). Consequently, it will generate conservative numbers in our analysis.

The calibration curves relating weight of solids present to counting efficiencies are not done in alpha/beta analysis, but currently are being evaluated.

3.6 Radiochemical Methods for Selected Radionuclides. Methods for a selected list of radionuclides are listed in Table 1. The radionuclides listed are those which are most commonly used and which hove the greatest potential for causing doses to members of the public. For radionuclides not listed in Table 1, methods based on any of the applicable "principles of measurement" described in section 3.1 through 3.4 may be used.

Response: The air samples from the main stacks are well characterized. Some of the radionuclides identified (^{241}Am, ^{238}Pu, $^{239,240}Pu$, ^{90}Sr, ^{134}Cs, ^{137}Cs, ^{144}Ce, ^{147}Pm, ^{14}C, ^{3}H, and ^{131}I) are listed in Table 1 of Method 114 (EPA 1991) and are analyzed according to the approved methods given in the table. Other radionuclides (^{95}Nb, ^{95}Zr, ^{129}I, $^{106}Rh/^{106}Ru$, ^{113}Sn, ^{125}Sb, and ^{103}Ru) not listed in the table are analyzed by the methods outlined in Method 114, depending on the type of emitted radiations. It is important to note here that the radionuclides ^{95}Zr, ^{95}Nb, and ^{103}Ru have nearly decayed to nondetectable levels because no product is being produced.

3.7 Applicability of Gross Alpha and Beta Measurements to Unidentified Mixtures of Radionuclides. Gross alpha and beta measurements may be used as a screening measurement as a part of an emission measurement program to identify the need to do specific radionuclide analyses or to confirm or verify that unexpected radionuclides are not being released in significant quantities.

Gross alpha (Method A-4) or gross beta (Methods B-2 or B-4) measurements may also be used for the purpose of comparing the measured concentrations in the effluent stream with the limiting "Concentration Levels for Environmental Compliance" in Table 2 of Appendix E. For unidentified mixtures, the measured concentration value shall be compared with the lowest environmental concentration limit for any radionuclide which is not known to be absent from the effluent stream.

Response: This is not applicable because the air effluents from the Hanford Site main stacks are well characterized. However, gross alpha and beta analyses for weekly and daily air samples are routinely performed in the 222-S Laboratory before starting specific radionuclide analyses. Following this practice, the facility can verify a significant release of a radionuclide into the air so corrective actions to minimize radionuclide emission into the environment can be taken promptly by facility personnel. The gross alpha and beta results from analysis are compared to

those listed in the appendix of DOE Order 5400.5 (DOE 1990) for compliance.

4.0 Quality Assurance Methods

Each facility required to measure their radionuclide emissions shall conduct a quality assurance program in conjunction with the radionuclide emission measurements. This program shall assure that the emission measurements are representative, and are of known precision and accuracy and shall include administrative controls to assure prompt response when emission measurements indicate unexpectedly large emissions. The program shall consist of a system of policies, organizational responsibilities, written procedures, data quality specifications, audits, corrective actions and reports. This quality assurance program shall include the following program elements:

4.1 The organizational structure functional responsibilities, levels of authority and lines of communications for all activities related to the emissions measurement program shall be identified and documented.

4.2 Administrative controls shall be prescribed to ensure prompt response in the event that emission levels increase due to unplanned operations.

WHC-CM-4-12, Section 1.14, REV 0, ALARM RESPONSE AND MANAGEMENT (WHC 1992b)-- provide guidance and sets requirements for managing the responses to alarms which are the responsibility of Occupational Health and Safety (OHS). This practice is applicable to all members of the Occupational Health and Safety organization. Area Health and Safety managers shall ensure that all members of their organizations are aware of and adhere to this practice.

WHC-CM-4-12, Section 2.1, REV 0, RADIOLOGICAL PROBLEM REPORTING PROGRAM--The purpose of the Radiological Problem Report (RPR) program is to provide a documented record of observed radiological problems, a mechanism for reporting these problems to management for action, a capability to track and monitor the progress of the planned corrective actions and a database for assessing trends in radiological program performance and needed actions.

WHC-CM-4-12, Section 12.1, REV 1 EMERGENCY RESPONSE--An EMERGENCY is a sudden unexpected event requiring immediate response to mitigate impacts to people, property, or the environment. When radioactive material is involved, Health Physics (HP) plays a major role in evaluating, controlling, and recovering from the event. To be able to perform this function HP personnel receive training to respond to a variety of emergency situations. HP procedures are written to provide guidelines to respond to emergencies. Together, the training and the written procedure detail the HP Emergency Response Program.

Emergency Response--HP personnel, in many situations are the first to respond to a radiological emergency. The ability to assess and evaluate the situation and take immediate steps to minimize the effects of the event is crucial for controlling the emergency. The HP personnel must use their training and experience to make good decisions during the initial response to an emergency.

An emergency response may be initiated by personnel observing the event, alarms, the Patrol Operation Center or the Emergency Control Center(s) once they are manned. For a planned response, HP personnel shall be in teams of at least two. Out of necessity (e.g., backshift response), one member could be an Operations

person, or other emergency service person such as fire or patrol. A rapid response is required; however, no undue risks should be taken nor should employee personnel safety be compromised. The type of emergency determines the level of planning for HP response. For example, a Continuous Air Monitoring (CAM) alarm or a small radioactive spill, requires little planning for the initial response. However, when an emergency causes a facility evacuation, preplanning (e.g., stay time, entry route) and approval of the Building/Facility Emergency Director is necessary for a re-entry.

Although HP personnel respond to an emergency using basic guidelines, an area/facility may have specific procedures which have priority over these guidelines.

WHC-IP-0692, 12.1.2.3, Rev 2, EFFLUENT EXHAUST CAM ALARM RESPONSE (WHC 1991b)--This procedure establishes the standard method of handling samples from, and response to alarms at, Effluent Exhaust CAM systems. This procedure describes the steps and material necessary to exchange, perform field concentration calculations, and submit suspect samples for "rush" or "Red Envelope" analysis, when responding to alarms on Effluent Exhaust CAM systems.

WHC-IP-0692, 12.1.6, REV 1, STACK EFFLUENT RELEASE RESPONSE (WHC 1991b)--This procedure establishes guidelines for responding to a potential or actual release of radioactive material through exhaust stacks. This procedure describes the immediate actions to respond to an exhaust (CAM) stack alarm. (i.e., CAM monitoring downstream or upstream of the final filtration)

WHC-IP-0692, Procedure No. 12.2.1, Rev. 2, EMERGENCY RESPONSE AIR SAMPLING (WHC 1991b)--This procedure establishes the instruction and guidelines for air sampling in an emergency situation. This procedure describes the steps for air sampling both inside and outside facilities when a release of radioactive material is suspected.

WHC-IP-0692, 12.2.3, REV 0, HEALTH PHYSICS EMERGENCY RESPONSE TEAM (WHC 1991b)--This procedure provides the organizational structure of, the instructions for, and the responsibilities of the HP Emergency Response Team and the Health Physics Technician (HPT) Field Survey Teams. This procedure describes the steps for an initial emergency response by the HP Emergency Response Team (ERT) and HPT Field Survey Teams. The HP ERT and the HPT Field Survey Teams may be requested to respond to an emergency when it is deemed that an environmental release of radioactive material may extend beyond the of control of a facility or outside the boundaries of the Hanford Site. These teams will have monitoring responsibilities only outside the boundaries of the event site.

WHC-IP-0692, 12.2.4, Rev. 2 EMERGENCY RADIOACTIVE PLUME TRACKING--This procedure establishes the instructions to track a plume created from a radioactive material release to the environment. This procedure describes the steps to track and to determine if a

radioactive beta-gamma plume is at ground level or at an elevated level.

Notifications and reporting of specific events related to environmental releases and/or events involving effluents and/or hazardous materials are reported via instruction given in WHC-CM-5-34, Solid/Liquid Waste Remediation Operations Administration, Section 1.18, Occurrence Reporting and Processing of Operations Information (WHC 1992b). The purpose of this procedure is to establish and implement specific criteria and requirements for the identification, categorization, notification, and reporting of occurrences within the Solid/Liquid Waste Division, including the 340 facility, as required by WHC-CM-1-3, MRP 5.14, "Occurrence Reporting and Processing of Operational Information."

4.3 The sample collection and analysis procedures used in measuring the emissions shall be described including where applicable:

4.3.1 Identification of sampling sites and number of sampling points, including the rationale for site selections.

Drawings H-2-93415, *291-T-1 Stack Monitor Installation* and BPF-70174, *Concrete Stacks, The Rust Engineering Company*, show stack dimensions and sampling site location. As shown, The stack is constructed with reinforced concrete and has an acid-proof brick lining. The stack is 200 ft high with an inside base diameter of 7 ft. The stack tapers to an inside diameter of 5 ft at the top. The sample site is located at the 50-ft level of the stack. The sample site is located 40 ft downstream (or 6.6 average duct diameters) from the last disturbance and 150 ft (or 25 average duct diameters) from the point of release. The stack has one isokinetic probe with 10 sample nozzles. This location meets the criteria specified in 40 CFR 60, Appendix A, Method 1.

4.3.2 A description of sampling probes and representativeness of the samples.

The sample, as shown on drawing H-2-93414, *Stack Monitor Probe Assembly 291-T-1*, consists of a single sample probe with 10 sample nozzles. The inside diameter of each nozzle is 0.37 in. and each covers 3.3 ft^2 of area. Although a velocity distribution is not known, the flow can be shown to be turbulent.

The stack diameter, as shown on drawing BPF-70174, *Concrete Stacks by the Rust Engineering Company*, shows an average stack diameter of 6 feet. Drawing H-2-93414, *Stack Monitor Probe Assembly 291-T-1*, gives the stack flow velocity as 808.7 ft/min. Given this and the information provided in ANSI N13.1-1969, it can be proven that the Reynolds number (Re) exceeds 2100, the point at which flow is assumed to be turbulent.

$$Re = \frac{(dia.)(velocity)(density)}{viscosity}$$

$$Re = 5E5 = \frac{(183\ cm)(410.8\ cm/sec)(0.0012\ g/cm^3)}{(0.00018\ g/cm\text{-}sec)}$$

As stated in the ANSI Standard, Section A3.3.2, "as the flow becomes more turbulent, the velocity becomes more nearly uniform across the duct." Based on this, the sampling probe is assumed to be isokinetic.

4.3.3 A description of any continuous monitoring systems used to measure emissions, including the sensitivity of the system, calibration procedures and frequency of calibration.

Not applicable; emissions are not monitored continuously for compliance purposes.

4.3.4 A description of the sample collection systems for each radionuclide measured, including frequency of collection, calibration procedures and frequency of calibration.

The sampler runs continuously to ensure a representative sample. Radioactive particulates are captured on a HEPA as described in Section 2.1 of WHC-EP-0536. Samples are collected weekly, in accordance with the procedures WHC-IP-0692, "Operation of Gaseous Effluent Sampling and Monitoring System and Occupational Health and Safety - Scheduled Radiation Survey Task Description" (WHC 1991b). There are no calibrations required for the particulate filter or the charcoal cartridge.

4.3.5 A description of the laboratory analysis procedures used for each radionuclide measured, including frequency of analysis calibration procedures and frequency of calibration.

- Total alpha-total beta activity is determined by procedure LA-508-110 or LA-508-114 on weekly samples, and occasionally on daily air samples, per collection point. The calibration procedure is documented in LQ-508-002. It is done only when deemed necessary by a responsible scientist. The counting system is recalibrated only in case of (1) major repairs or adjustments to the power supply or detector or (2) calibration shift as indicated by the instrument control standards. The performance of the counting systems is checked by running the instrument control standards (^{147}Pm for low-energy beta, ^{60}Co for mid-energy beta, ^{137}Cs for high-energy beta, and ^{241}Am for alpha activity) separately. When a batch of air filter samples is run, all the performance standards and the background (for counting frequency refer to LO-150-115) also are run with it. To verify that the counting system is working properly, the standard values from analysis should fall within the

administrative limits set according to appropriate quality assurance program plans (QAPP).

- Our laboratory method for analysis of alpha emitters (^{241}Am, ^{238}Pu, and $^{239,240}Pu$) involves various steps (LA-549-112 for dissolution, LA-943-123 for chemical separation, LA-542-101 for electrodeposition, and LA-508-051 for final alpha spectrometry). The analysis of alpha emitters is done on a quarterly composite of weekly/daily air filter samples. The energy resolution and calibration of the AEA system over the energy range of 4 to 6 MeV are checked once a month by the preventive maintenance (PM) procedure 2S18006. Efficiency calibration of the AEA is not needed in our analysis method because direct comparison of the sample with recoveries of the tracers (^{243}Am and ^{236}Pu) is made to determine the activities of the radionuclides present in the sample. To carry out the sample analysis, AEA system performance is checked once every 24 hours for alpha energy shift with a certified mixed alpha source standard. Each alpha energy peak identified in the standard must fall within administratively assigned certain channels (+10) on the MCA. For counting frequency of performance check standards, procedure LO-150-115 is referred to. The recovery of the radionuclides and the calibration of the system are checked on a batch basis by running a method standard under the identical conditions as the sample.

- The lab method for determining beta activity (^{89}Sr, $^{90}Sr/^{90}Y$) consists of a dissolution step (LA-549-112), chemical separation (LA-220-103), and total beta counting (LA-508-111). Analysis is done on a quarterly composite of weekly/daily air filter samples per collection point. The calibration procedure LQ-508-002 (for window-type gas flow proportional counter) is used in conjunction with LQ-508-005 (for mother/daughter case, i.e., $^{90}Sr/^{90}Y$ in growth calibration). It is performed only when the responsible scientist finds it necessary. The reasons are the same as stated for total alpha/total beta. The performance of the counting system is checked once per shift by running instrument control standards (^{60}Co, ^{137}Cs, and ^{147}Pm for beta activity). The complete procedure for the $^{90}Sr/^{90}Y$ analysis in the sample is carried out with a method standard (several filter papers spiked with ^{90}Sr, ^{147}Pm, ^{60}Co, ^{241}Am, ^{239}Pu, and U) provided by the 222-SA Standard Laboratory) on a batch basis. This checks the overall performance of our method. The chemical yield is determined by using appropriate carrier.

- Determination of beta activity (^{147}Pm, ^{14}C, and ^{3}H) involves processing (LA-549-112 and LA-613-111 for

^{147}Pm, LA-348-101 for ^{14}C, and LA-218-112 for ^{3}H), mounting in scintillation cocktail (LA-508-111), and finally, liquid scintillation counting (LA-508-121). The ^{147}Pm analysis is done on quarterly composites of weekly/daily air filter samples. The ^{14}C and ^{3}H analyses are done on biweekly gas samples. For calibration, the quality assurance (QA) section of procedure LA-508-121 is referenced. The calibration of the instrument is checked by the manufacturer's supplied sources (^{14}C and ^{3}H) and its software.

For ^{147}Pm analysis, the method standard is run once per quarter. The method standard is always run with a batch of samples for ^{3}H and ^{14}C analysis. The results of the method standard checks the overall performance, including the calibration of the counting system. The instrument calibration check is done a minimum of once a week (refer to LO-150-115).

- For analysis of gamma emitters ^{95}Nb, ^{95}Zr, ^{134}Cs, ^{137}Cs, and ^{144}Ce the procedure LA-508-052 is followed. Analysis is done on quarterly composites of weekly/daily air filter samples. For analysis of volatile radionuclides (^{129}I, ^{131}I, $^{106}Rh/^{106}Ru$, ^{113}Sn, ^{125}Sb, and ^{103}Ru) collected weekly on silver zeolite cartridge, the procedure LA-288-101 is used in conjunction with procedure LA-508-052. Calibration of the gamma ray spectrometer is done with the procedure documented in LQ-508-003 using a (NIST traceable) certified mixed gamma ray standard. It is carried out only when it is deemed necessary by a responsible scientist. To check efficiency and energy calibration daily, the performance of each detector of the GEA system over the whole energy range is done once every shift by running a mixed gamma standard consisting of ^{241}Am for low energy, ^{137}Cs for mid energy, and ^{60}Co for high energy. The results of each of these radionuclides should fall within the administrative limits set according to the appropriate QAPP to continue analysis of samples. The daily performance results are documented. Minor adjustments of the electronics (e.g., fine gain, pole zero of the amplifiers, lower level discriminator of analog-to-digital converter) are done from time to time when necessary for proper energy calibration. Whenever a minor electronic adjustment is done on a detector, it is followed by analysis of a performance standard. For a major shift in the calibration, the system is then thoroughly calibrated using LQ-508-003.

- The content of the 222-S Laboratory's procedures, test plans, supporting documents, and drawings provide a sufficient level of detail to allow trained personnel to produce quality results safely. Laboratory procedures are controlled as required by WHC-CM-5-4,

Section 5.4, "Analytical Laboratory Procedures." The specific content of laboratory procedures is defined by its author, based on accepted methods such as 40 CFR 61, Appendix B, Method 114 (EPA 1991). The content must be agreed to by the peer and technical reviewers. While authors are responsible for the specific content of their procedures, they address the topics below.

Summary--MANDATORY--A short description or abstract of the procedure containing enough information to distinguish it from other procedures.

Applications--MANDATORY--Defines the scope and purpose of the specific procedure. This section may be combined with the following element under the title "Applications and Limitations."

Limitations--MANDATORY--Briefly describes those areas in which the procedure is not applicable. A statement of accuracy and precision will be given where appropriate.

Quality Control Protocol--Procedures used to support environmental projects that have specific quality control requirements. For these procedures, the source of the quality control requirements will be identified. The samples or project that this element applies to will be identified. The following information is typical of quality control requirements: frequency and type of calibration, reagent blank analysis, spike sample analysis, and duplicate sample analysis.

Impact Level Identifier--MANDATORY--An impact level will be identified for each procedure following WHC-CM-1-3, MRP 5.43, with a brief basis of determination statement. This MRP lists several descriptive paragraphs delineating what constitutes an Impact Level 1, 2, 3, or 4 activity. The following parts of MRP 5.43 cover most analytical laboratory procedures.

1. Section 5, paragraph 6, part c., Impact Level 3--work authorization documentation associated with work involving occupational hazards not covered by approved procedure, such as Operational Safety Assessments, Radiation Work Permits, or Industrial Safety Standards.

2. Section 5, paragraph 6, part c., Impact Level 4--Documentation for any activity not classed as Impact Level 1, 2, or 3.

The laboratories' procedures are usually specific to one activity. These activities are well defined using common scientific instrumentation and equipment operated in an acceptable manner. The chemicals and materials used are

normally small quantities with limited potential for environmental or personnel safety impact. In general, the equipment used in the laboratory is not classified as Safety Class 3 or higher.

Safety--MANDATORY--The procedure must identify applicable safety hazards.

The following documents identify Hanford Site safety requirements:

- WHC-CM-4-3, Volume 1-3, *Industrial Safety*
- WHC-CM-4-10, *Radiation Protection*
- WHC-CM-4-15, *Radiation Work Requirements and Work Permits Manual*
- WHC-CM-4-29, *Nuclear Criticality Safety*.

Supporting document WHC-SD-CP-LB-003, *Safety in the Analytical Laboratory*, is the laboratory general safety document. The authors must review safety requirements and include safety warnings appropriate to the actions directed by the procedure.

Reagents--If the procedure requires analytical reagents, a list of reagents will be provided. The material safety data sheets (MSDS) number will be placed in brackets by each chemical name. Reagent makeup, storage container requirements, unique storage needs, shelf-life requirements, special labeling, and special preparation steps will be included. Special notations for any known or suspected carcinogen as listed on WHC-CM-4-3, Volume 2, Table 1, "WHC Master Carcinogen List," will be made on the reagent list.

Reagent preparation described fully in other current Hanford Site documentation may be included by reference.

Equipment--Special equipment needs will be listed. Standard hood or glovebox equipment is assumed to be available at the work station and does not need to be listed. The fabrication of off-standard equipment will be referenced or described in this section.

Procedure Steps--MANDATORY--A step-by-step description of operations necessary to perform the task will be presented in a logical and sequentially numbered order or an assignment of responsibilities. CAUTIONS and WARNINGS notations will be included for the applicable safety hazard before the action is described. Steps with potential for criticality specification violation will be identified. Explanatory "Notes" may be included for clarification of process.

Calculations--Calculations required to complete the work will be described in this section. Examples with sample

values may be included. All combined factors will be fully described and units noted.

Calibrations--When calibrations are required, a description of how to carry out required calibrations will be given.

Discussion--A discussion of the theoretical aspects of the procedure. Brief identification of unique characteristics and interfaces to aid in troubleshooting may be included.

References--A reference list of published information to provide technical basis for the procedure may be included.

The mandatory topics are addressed in both procedures. However, the laboratories have technical, analytical, and administrative procedures. Non-mandatory topics are included if appropriate to the activity covered by the procedure.

The calibrations of all laboratory instruments are controlled by the Laboratory Instrument Calibration Control System (LICCS) (WHC-CM-5-4, Section 8.2). The LICCS documents the requirements for and the performance of calibration activities for each analytical instrument or measurement device.

Laboratory analysis procedures used for Stack 291-T-1 record samples are described by the information in Section 3.0.

4.3.6 A description of the sample flow rate measurement systems or procedures, including calibration procedures and frequency of calibration.

The sample flowrate is regulated using a rotameter. The visual float is verified weekly during sample collection in accordance with WHC-IP-0692, "Operation of Gaseous Effluent Sampling and Monitoring System" (WHC 1991b). Rotameters are scheduled for calibration semiannually. The calibration is completed in accordance with procedure, PSPC-7-001, "Calibration Procedures, Air Rotameter."

4.3.7 A description of the effluent flow rate measurement procedures, including frequency of measurements, calibration procedures and frequency of calibration.

4.4 The objectives of the quality assurance program shall be documented and shall state the required precision, accuracy and completeness of the emission measurement data including a description of the procedures used to assess these parameters. Accuracy is the degree of agreement of a measurement with a true or known value. Precision is a measure of the agreement among individual measurements of the same parameters under similar conditions. Completeness is a measure of the amount of data obtained compared to the amount expected under normal conditions.

The accuracy of analyses is checked using percent recovery. The evaluation of blind or known check standards provides the percent recovery.

For both blind and known check standards, percent recovery is calculated by the following equation:

$$P = 100 \cdot \frac{R}{S_t}$$

Where:

P = Percent recovery
R = Measured or recovered analyte concentration in the check standard
S_t = Concentration of analyte in the check standard.

The laboratories do not use manual W. A. Shewhart control charts (Shewhart 1931). The Laboratory Measurement Control System (LMCS) is a software package designed for support of management quality control decisions. Each analytical measurement system has different control parameter requirements based on the use of specific standards. The LMCS program provide a performance versus limits control chart for each standard. The average percent recovery (P) or 100%, depending on the method, marks the center of the limit. The upper and lower boundaries of the limits are multiples of the standard deviation (s) of the average percent recovery. The laboratory manager approves the LMCS limits, defined as P ± ns, where n is a positive number. The values for P and s are either performance based. In general, management sets the warning limits at 2s and the control limits at 3s or their equivalent.

When the LMCS identifies an out-of-control method, it automatically initiates corrective action. The system issues an Off Standard Condition Report (OSCR). The scientist in charge of the method must discover and resolve the problem to close out the OSCR. Until the OSCR has been clear, personnel can not perform any analyses by this method. After the scientist has resolved the problem, personnel evaluate all analyses performed since the last in-control point.

The laboratories assess precision by examining the results from split samples or laboratory duplicates. Percent relative difference measures the precision of analyses. Percent relative difference is computed by the following equation:

$$RD = 100 \cdot \frac{S_d}{X}$$

Where:

RD = Percent relative difference
S_d = The standard deviation estimate of the duplicate data set
$\bar{X}$ = The arithmetic mean (average) of the duplicate data set.

The initial QA objective for completeness of analyses in the laboratories is 90%. This means that the goal is to produce usable analytical data for a minimum of 90% of the analyses requested on all samples submitted to the laboratory. The laboratory evaluates actual performance against the 90% objective. If the laboratory performance drops below this limit, management initiates corrective action. This action shall identify and correct those activities within the laboratory that have caused the drop in performance. The objectives are documented in the Environmental Protection Quality Assurance Project Plan (QAPjP) (WHC 1992d).

4.5 A quality control program shall be established to evaluate and track the quality of the emissions measurement data against preset criteria. The program should include where applicable a system of replicates, spiked samples, split samples, blanks and control charts. The number and frequency of such quality control checks shall be identified.

The samples analyzed under this program consist of mounts made from preparation of stack filters. Each sample collection point produces only one sample which is sent to the laboratory for analysis. No replicate samples are available. Repeat measurement of individual samples are made at the discretion of the scientist in charge.

As a type of process control samples, stack filters are not subject to matrix effects and radionuclide spikes are not used. However, tracer elements ^{243}Am and ^{236}Pu support the analysis of ^{241}Am, ^{238}Pu, and ^{239,240}Pu in the quarterly composite of weekly filter samples.

The laboratory does not split samples. There is no guarantee that the distribution of material on the filter will be homogenous. Because of this, no subsampling procedure, such as splitting, can be assured of producing two representative portions. Also, splitting the sample in effect dilutes the sample, which would adversely effects the method detection limits.

Formal blanks are not available for these analysis. However, prior to the analysis of a batch of samples, the background of the counting instrument is checked. This background check as made on each planchet and planchet holder.

Control charts and standards used in support of these analysis are described in Section 4.4 of WHC-EP-0536.

Laboratory requirements are presented in Section 3.0 of WHC-EP-0536.

4.6 A sample tracking system shall be established to provide for positive identification of samples and data through all phases of the sample collection, analysis and reporting system. Sample handling and preservation procedures shall be established to maintain the integrity of samples during collection, storage and analysis.

See Section 6.2.3 of WHC-EP-0536.

4.7 Periodic internal and external audits shall be performed to monitor compliance with the quality assurance program. These audits shall be performed in accordance with written procedures and conducted by personnel who do not have responsibility for performing any of the operations being audited.

See Section 7.0 of WHC-EP-0536.

4.8 A corrective action program shall be established including criteria for when corrective action is needed, what corrective action will be taken and who is responsible for taking the corrective action.

See Section 8.0 of WHC-EP-0536.

4.9 Periodic reports to responsible management shall be prepared on the performance of the emissions measurements program. These reports should include assessment of the quality of the data, results of audits and description of corrective actions.

See Section 9.0 of WHC-EP-0536.

4.10 The quality assurance program should be documented in a quality assurance project plan which should address each of the above requirements.

The quality assurance program for stack 291-T-1 will be described in a future QAPjP.

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