NEW JERSEY STATE DEPARTMENT OF ENVIRONMENTAL PROTECTION
NEW JERSEY ADMINISTRATIVE CODE
TITLE 7, CHAPTER 27B-1
AIR TEST METHOD 5

# SAMPLING AND ANALYTICAL PROCEDURES FOR DETERMINING EMISSIONS OF PARTICLES FROM COMBUSTION OF WASTES

Promulgated: DRAFT
To Be Effective:

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References

## 7:27B-4.1    DEFINITIONS

Terms not defined in this section are intended to be used as defined in the New Jersey Air Pollution Control Code Act, N.J.S.A 26:2C-1, et seq. and the Administrative Code, Title 7, Chapter 27, or are used in their common engineering or scientific sense.  Symbols and nomenclature are defined in Appendix 9.

"Bureau" means the Bureau of Air Pollution Control.

"Department" means the Department of Environmental Protection.

"Equivalent Diameter" means the diameter of a circular cross section having the same area as a non-circular cross section.

"Integrated Gas Sample" means a sample taken either continuously or at regular frequent intervals (not more than five minutes apart) during the entire time period of each individual test run.

"Performance Test" or "Test" means a series of test runs used for the purpose of determining emissions of air contaminants to the outdoor atmosphere.

"Wastes" means Type 0, Type 1, Type 2, Type 3, Type 4, Type 5, and Type 6 as defined in N.J.A.C. Title 7, Chapter 27, Subchapter 11.1.

"Run" or "Test Run" means a single intergrated measurement of procedure used for the purpose of collecting a sample of air contaminants emitted to the outdoor atmosphere during a specified time interval.

"Sample collector" means any device used to selectively separate and collect a sample of a specified contaminant from a gas stream, including, but not limited to, thimbles, filters, impingers, bubblers, cyclones, condensers, and absorbers.

"Sampling location" means the specific position at which a sampling port is located in a stack or chimney.

"Sampling port" means an opening in a stack or chimney into which sampling or measuring devices may be inserted or through which a sample is extracted.

"Sampling rate" means the volume rate at which stack gases are drawn through a sampling train.

"Sampling train" means a combination of entrapment devices, instruments and auxiliary apparatus arranged in a prescribed sequence to selectively separate and collect samples of specified air contaminants.

"Sampling velocity" means the linear velocity at which stack gases are drawn through the nozzle of a sampling train.

"Standard conditions" means 70 $^o$F and one atmosphere pressure (14.7 psi or 760 mm Hg).

"Traverse point" means a predetermined point at which a sample or measurement is obtained inside a stack or chimney.

## 7:27B-4.2    ACCEPTABLE TEST METHODS

(a)      Because of size and /or inertial effects on the particles to be measured, they are to be collected under isokinetic conditions to ensure that the sample is representative.  With isokinetic sampling, that portion of the gas stream from which the particles are entrapped is made to enter the sampling nozzle in the same velocity as the gas stream in the stack or chimney being sampled.  The sample weight is determined gravimetrically after removal of uncombined water.  Determination of % isokinetic shall be in accordance with Appendix 3.

(b)      Performance tests shall be conducted in accordance with test methods set forth hereinafter. Alternate test procedures, equipment and/or materials of construction may be used subject to prior

approval and/or conditions prescribed by the Department.  The Department may itself employ such alternatives when warranted by test conditions or other circumstances.

## 7:27B-4.3    OPERATING CONDITIONS DURING THE TEST

Insofar as practical, the incinerator will be tested while operating at normal routine conditions and, as necessary, at other conditions including but not limited to, design, maximum and fluctuating rates, and the types of wastes incinerated.

(a)     The owner or operator of the source operation to be tested shall be responsible for providing the following testing facilities upon request by the Bureau:

1.     Sampling ports installed at locations specified by the Bureau and of a size large enough to accommodate the sampling equipment.

2.     Safe sampling platform(s) and safe access thereto conforming with laws and regulations concerning safe construction and safe practice (Reference 1)

3.     Utilities as needed for sampling and testing equipment.  This may include electrical power and water.

4.     Any other facilities exclusive of instrumentation and sensing devices as may be necessary for the Bureau to accurately determine the emission of particles from the source operation.

5.     Facilities as necessary for representative sampling of fuel and determination of the amount being burned during the test run.

6.     Facilities as necessary for representative sampling of the "wastes" and for the determination of the amount of the "wastes" being combusted during the test run.

7.     The facilities installed may be either permanent or temporary, at the discretion of the person responsible for their provision.

## 7:27B-4.5    SAMPLING TRAIN

The sampling train normally used by the Department is shown on Page 1 of Appendix 1 and shall consist of the following:

(a)     A sampling nozzle (A)* made of stainless steel (316) and having a sharp tapered leading edge.  Its internal diameter shall be of an appropriate size to permit a sampling rate that is as close as possible to 0.75 CFM at isokinetic conditions.

(b)     A glass-lined stainless steel probe (B)* with a heating system capable of maintaining the temperature of the sample gas passing through it sufficiently high to prevent condensation of water from occurring, but not to extend 225 $^{\circ}$F, and a temperature sensor $(T_1)$* to indicate the sample gas temperature.

(c)     A high-vacuum hose (c)* with a smooth, inert inner wall and with a heating system capable of maintaining the temperature of the sample gas passing through it sufficiently high to prevent condensation of water from occurring, but not to exceed 225 $^{\circ}$F, and a temperature sensor $(T_2)$* to indicate the sample gas temperature.  In lieu of this hose, direct coupling of the probe (B)* and the glass cyclone and filter assembly $(D_1$ and $D_2)$* may be used.

(d)     A sample collector consisting of a glass cyclone ($D_1$)* followed by a glass fiber filter (Reeve-Angel 934AH**, MSA 1106BH** or approved equivalent) in a glass holder ($D_2$)*. The cyclone and filter assembly shall have a heating system (D)* capable of maintaining the temperature of the sample gas passing through it sufficient high to prevent condensation of water from occurring, but not to exceed 225 $^o$F, and a temperature sensor ($T_3$)* to indicate the sample gas temperature. The use of the cyclone is optional when it is not necessary to prevent the filter from being overloaded by large particles.

(e)     A condenser system (E)* consisting of a Greenburg-Smith impinger ($E_1$)* containing 100 ml. distilled water followed by a modified Greenburg-Smith impinger ($E_2$)* (dry) for mist knockout, both immersed in an ice bath. The use of more than one Greenburg-Smith ($E_1$)* impinger containing 100 ml. of distilled water is optional.

(f)     A drying tube (F)* containing Drierite** or silica gel.

(g)     A hose (G)* capable of holding a vacuum of at least 15 inches of mercury.

(h)     A leak-free pump (H)* with coarse ($H_1$)* and fine ($H_2$) flow control adjusters and vacuum gauge (P)*.

(i)     A dry gas test meter (I)* accurate within 2% and temperature sensors ($T_4$)* to indicate the sample gas inlet and outlet temperatures.

(j)     An orifice meter (J)* with an inclined manometer ($M_2$)* as described in APCO Publication APTD-0581 (Reference 2).

(k)     A thermocouple (K)* attached to the probe (B) with its sensing portion adjacent to the sampling nozzle (A)* and equipped with a temperature sensor ($T_5$)* to indicate the stack gas.

(l)     An "S" type pitot tube (L)* attached to the probe (B)* with its sensing portion adjacent to the nozzle and equipped with a differential pressure gauge ($M_1$)* (inclined manometer or equivalent) to measure velocity head to within 10% of the minimum value as determined during the preliminary traverse.

(m)     All glassware (cyclone, filter holder, and impingers) should be interconnected with glass fittings having ball joints.

NOTES:
1.     When tests are performed to determine actual or potential emission, all outlets will be sampled simultaneously.
2.     All measuring devices including, but not limited to, pitot tubes, meters, gauges, and thermocouples shall be properly calibrated and maintained to provide accurate data. Records of such calibration must be maintained and may be requested by the Department.

## 7:27B-4.6     PERFORMANCE TEST PRINCIPLES

For purposes of measuring emissions in accordance with applicable provisions of the rules of the Bureau of Air Pollution Control, particles shall be drawn by isokinetic procedures from the stack or chimney and the weight of the particles determined gravimetrically after removal of uncombined water. The measured emission weight shall be the combined weight of all particles collected and analyzed in accordance with this sampling and analytical procedure.

## 7:27B-4.7    GENERAL TESTING REQUIREMENTS

All tests shall be conducted in accordance with the following:

(a)    The sampling location and number of traverse points shall be determined by E.P.A. Method 1 (Reference 3).

(b)    Determination of stack gas velocity shall be by E.P.A. Method 2 (Reference 3) and calculation #3 in Appendix 4.

(c)    An integrated gas sample for $CO$, $CO_2$, $O_2$, and by difference $N_2$ shall be taken during each individual test run.  An orsat analyzer shall be used, and the calculations from Appendix 6 shall be used for stack gas molecular weight and correcting grain loading to 12% $CO_2$ (Appendix 5).

(d)    Stack gas moisture content shall be determined by the increase in volume of the impinger and the increase in weight of the drying tube and calculations in #1 of Appendix 6.

(e)     Unless otherwise specified by the Department, each performance test consists of not less than three separate and valid one-hour test runs.

(f)    For the purpose of determining compliance with any applicable standard, the results of each valid test run (see Section 4.13) shall be considered.

## 7:27B-4.8    REQUIRED TEST RUN

Test data to be determined and reported for each test run must include the following (see Appendix 7) for recommended reporting form:

(a)    Average dry gas meter temperatures ($^o$F) during each test run.

(b)    Average stack temperature ($^o$F) during each test run.

(c)    The root mean square value of differential pressures (inches of water) of all traverse points in the stack during each test run.

(d)    Average differential pressure (inches of water) across the orifice meter during each test run.

(e)    Equivalent diameter (inches) of the stack cross-sectional area at sampling location.

(f)    Weight (grams) of total particles collected (see subsection 4.12(a)9) during each test run.

(g)    Percent of moisture by volume in stack gas during each test run, as determined by the procedure described in E.P.A. Method 5 (Reference 3).

(h)    Volume of gas (cubic feet) sampled at meter conditions during each test run.

(i)    Source gas emission rate (standard cubic feet per minute).

(j)    The potential emission concentration (grains per dry standard cubic foot) during each run, when necessary.

(k)     Emission concentration to the atmosphere (grains per dry standard cubic foot) during each run.

(l)     Percentage of $CO_2$, CO, $O_2$ and $N_2$ by Orsat analysis of the stack gas being sampled.  The samples should be taken prior to any wet scrubbing system if possible.*  The resulting $CO_2$ determinations shall exclude the contribution of $CO_2$ from the combustion of auxiliary fuel.

(m)     Molecular weight (Ms) of the outlet stack gas.

(n)     Emission concentration to the atmosphere (grains per dry standard cubic foot corrected to 12% $CO_2$, excluding the contribution of $CO_2$ from the combustion of auxiliary fuel) during each run.

(o)     Emission concentration to the atmosphere (grains per dry standard cubic foot corrected to 7% $O_2$) during each run.

(p)     The type of waste and amount charged to the incinerator during each test run.

(q)     The type of auxiliary fuel and amount burned in the incinerator and afterburners, if present, during each test run.

(r)     If the amount of $CO_2$ from the combustion of auxiliary fuel is to be determined stoichiometrically, a bonafide analysis of the fuel will be necessary (Appendix B).

*For determining grains/dscf.

NOTE:

Field notes, laboratory notes, calculations, and charge data and information must be included with test reports submitted to the Department.


**7:27B-4.9     PREPARATION FOR SAMPLING**

(a)     Each filter is assigned a control number for identification.  The filter is dried in an oven at 220-230$^o$F, cooled in a desiccator to room temperature and then weighed on an analytical type balance to the nearest 0.1 mg. The cycle shall be repeated as many times as necessary to attain a constant weight, which is then recorded.  The filter is then placed in a Pyrex glass filter holder with the openings sealed with clean rubber stoppers.

(b)     The drying tube shall be filled with sufficient Drierite or silica gel to remove the moisture from the gas stream being sampled.  Normally, 200-300 grams will serve the purpose.  The drying tube plus the desiccant is weighed to the nearest gram, sealed immediately with clean rubber stoppers and marked for identification.  The total weight is recorded.

(c)     Assemble the sampling train (after selecting the proper sampling nozzle) in accordance with the drawing (Appendix 1).

(d)     Place 100 mls. of distilled water in the Greenburg-Smith impinger(s) (E1).  Place crushed ice around the impingers prior to the start of the test run and add more ice as necessary during the test runs.

(e) Check the sampling train for leaks before each run by plugging the nozzle and pulling a 15-inch mercury vacuum. A leakage rate of no more than 0.02 CFM is acceptable.

(f) Activate the heating systems of the probe, hose cyclone, and filter so that the internal gas is at the proper temperature (subsection 4.5(b), (c), and (d)).

## 7:27B-4.10 SAMPLING

(a) To begin sampling, position the nozzle at the first traverse point with the tip pointing directly into the gas stream. Record the dry gas meter volume at the beginning of the test run. Immediately start the vacuum pump and adjust the flow to the isokinetic conditions. Sampling time should be equal for each point.

(b) Stack temperature, meter temperatures, and differential pressures (as measured by the pitot tube and the orifice meter) during sampling shall be recorded for each sample point.

(c) At the conclusion of the test run, turn off the pump and record the final dry gas meter volume. After deactivating the heating systems, remove the probe and nozzle from the stack, conduct a post-test leak check as described in (d) and handle in accordance with sample recovery procedure described below (Section 4.11).

(d) Check the sampling train for leaks after each run by plugging the nozzle and pulling a vacuum equal to or greater than the maximum value reached during the run. A leakage rate of no more than 0.02 CFM is acceptable.

(e) When necessary, a representative sample of the waste being incinerated and/or the fuel being burned during the test run will be taken. The sample will placed into an appropriate container which is to be sealed and marked for identification.

## 7:27B-4.11 SAMPLE RECOVERY

(a) Exercise care in removing the sample to avoid loss of collected sample or gain of extraneous particles.

(b) Remove the filter holder ($D_2$)*, reseal the openings with clean rubber stoppers, and complete marking for identification.

(c) Remove the crying tube (F)*, reseal the openings with clean rubber stoppers, and complete marking for identification.

(d) Remove the impingers (E1 and E2)*, reseal the openings with clean rubber stoppers, and complete marking for identification.

(e) Wash all sample-exposed surfaces between the nozzle and the glass fiber filter holder, including the cyclone and the flask, with acetone. Use a razor blade, brush or rubber policeman to dislodge adhering particles. Place all loose particles and acetone wash in a clean sample bottle, seal and label for identification.

(f) Place about 100 ml. of acetone from the same container used for the wash in a separate clean sample bottle, seal, and label for identification (acetone blank).

(g)     Wash any exposed surfaces between and including the back half of the glass fiber filter holder and the Greenburgs-Smith impinger with distilled water.

**7:27B-4.12     ANALYSIS**

(a)     Record the data required on the Laboratory Report Form (see Appendix 2 for recommended reporting form).  Handle each sample as follows:

(1)     Transfer the filter and any loose particles from the glass holder ($D_2$)* to a tared weighing dish, dry, and desiccate to a constant weight (as in preparation).  Report results to nearest 0.1 mg.

(2)     Wash the glass holder ($D_2$)* (for filter) with acetone and add to the acetone wash sample bottle (subsection 4.11(e)).

(3)      Measure the volume of the acetone wash (subsection 4.11(e)) in ml., then evaporate to dryness at $70^o$F and one atmosphere in a tared beaker, heat to 220-$230^o$F, desiccate at room temperature and weigh to a constant weight.  After adjusting for the blank, the results are reported to the nearest 0.1 mg.

(4)     Measure the volume of water in the impingers to the nearest 1.0 ml. and record.  Add the distilled water washout to the impinger water before continuing with the analysis.

(5)     Filter the impinger solution through a tared Gooch crucible, fitted with a glass fiber filter disc (Reeve-Angel 934AH** or approved equivalent).  Dry the filter at 220-$230^o$F, desiccate at room temperature, and weigh to constant weight.  Report results to the nearest 0.1 mg.

(6)     Extract the organic particulate from the impinger solution first with three 25 ml. portions of chloroform and then with three 35 ml. portions of ethyl ether.  Combine the chloroform and ethyl ether extracts, transfer to a tared beaker and evaporate at about $70^o$F until no solvent remains.  Desiccate and weigh to a constant weight.  Report the results to the nearest 0.1 mg.

(7)     The impinger solution remaining after extraction is evaporated to dryness in a tared beaker at 220-$230^o$F, desiccated at room temperature and weighed to constant weight.  Report the results to the nearest 0.1 mg.

(8)     Weigh the drying tube to the nearest gram after removing the seals and record the weight. Each gram of increased weight equals one ml. of water.  This volume plus the volume collected in the impingers (subsection 4.11(d)) represents the total moisture in the gas sampled and is used to determine the percent moisture in the stack gas.

(9)     The total weight of particles collected corrected to 12% $CO_2$ is the sum of the weighs of particles as determined in subsection 4.12(a)1, 4.12 (a)3, 4.12(a)5, 4.12(a)6, and 4.12(a)7.

(10)    The total weight of particles collected corrected to 7% $O_2$ is the sum of the weights of particles as determined in subsection 4.12(a)1, and 4.12(a)3.

(b)  Analysis on the waste being incinerated and/or the fuel being burned will be conducted in a manner approved by the Department.

## 7:27B-4.13   VALIDATION OF TEST

Any test run during which the average percent isokinetic sampling rate (Appendix 3) is less than 90% or greater than 110% shall not be valid.

## 7:27-B-4.14   SIMULTANEOUS VISUAL AND ODOR EMISSION TESTS

When particulate emission tests are conducted on an incinerator, observations for visible emissions (section 4.15 and 4.16) and odors (section 4.17) as set forth should be made simultaneously with the tests.

## 7:27B-4.15   VISUAL DETERMINATION OF THE OPACITY AND SHADE APPEARANCE OF EMISSIONS

The opacity and shade or appearance of emissions from incinerators shall be determined in accordance with the procedures prescribed by N.J.A.C. 7:27B-2, Air Test Method 2, "Procedures for the Visual Determination of Opacity (percent and Shade or Appearance Ringelman Number) of Emissions from Sources".

## 7:27B-4.16   VISUAL DETERMINATION OF PARTICLES INDIVIDUALLY LARGE ENOUGH TO BE VISIBLE

(a)  The emissions of particles of unburned waste of ash which are individually large enough to be visible while suspended in the atmosphere is determined visually by an observer.

(b)  The observer shall stand at a distance sufficient to provide a clear view of the emissions. All observations will be recorded on an appropriate form.

## 7:27B-4.17   ODORS

(a)  The presence of odors being detectable by sense of smell in any area of human use or occupancy shall be determined by an observer.

(b)  The observer shall be positioned downwind in the direction of the plume of the incinerator in any area of human use or occupancy and shall record his observations on an appropriate form.

# REFERENCES

1.      New Jersey Administrative Code Title 12, Chapter 115, 116, and 180 are available from the Department of Labor and Industry, Bureau of Engineering and Safety, Post Office Box 709, Trenton, New Jersey 08625.

2.      APCO Publication No. APTD—0581—Construction Details of Isokinetic Source-Sampling Equipment, is available from the Office of Technical Information and Publications, Air Pollution Control Office, U.S. Environmental Protection Agency, Post Office Box 12055, Research Triangle Park, North Carolina 27709.

3.      Federal Register, Volume 42, Number 160, Part 60, August 18, 1977, is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402, and includes the following Environmental Protection Agency test Methods:

        Method 1 – Sample and Velocity Traverses for Stationary Sources

        Method 2 - Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube)

        Method 3 – Gas Analysis for Carbon Dioxide, Excess Air, and Dry Molecular Weight

# APPENDIX 1

The original Appendix 1 has not been reproduced here. The sample train generally employed for this method is as described in EPA Method 5, which can be downloaded from the EPA Emission Measurement Center (www.epa.gov/ttn/emc/promgate.html), with in-line thermocouples before and after the filter to monitor the sample gas temperature. The filter temperature is limited to being sufficiently hot to prevent condensation of water on the filter (generally 10-15$^o$F above stack temperature) not to exceed 225$^o$F. A post-test leak check conducted consistent with the procedures detailed for the pre-test leak check (7:27B-4.9(e)) is mandatory.

**APPENDIX 2**

**NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION**
**BUREAU OF AIR POLLUTION CONTROL**
**TECHNICAL SERVICES SECTION**
**LABORATORY REPORT – STACK SAMPLING**

NAME OF COMPANY_____

LOCATION OF STACK_____

STACK DESIGNATION_____(NJ NO._____)

ANALYSIS REQUIRED_____

SAMPLES COLLECTED BY_____DATE(S)_____

SAMPLES DELIVERED TO LAB BY_____DATE_____

SAMPLES RECEIVED AT LAB BY_____DATE_____

| A.S. NO. | FIELD NO. | RUN NO. | RESULT OF ANALYSIS | UNIT |
|----------|-----------|---------|--------------------|------|
|          |           |         |                    |      |
|          |           |         |                    |      |
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|          |           |         |                    |      |
|          |           |         |                    |      |

Report to be forwarded to_____

Analysis by_____

# LAB ANALYSIS SUMMARY

DATA

(A)     Filter Sample Wt.                                          _____gms.

(B)     Acetone Wash Vol.                                          _____ml.

(C)     Acetone Wash Part. Wt.                                     _____gms.

(D)     Acetone Blank Vol.                                         _____ml.

(E)     Acetone Blank Residue Wt.                                  _____gms.

(F)     Adjusted Acetone Wash Part. Wt.                            _____gms.

$$(F) = (C) - [ (B) \times (E) / (D)]$$

(G)     Wt. $H_2O$ Absorbed by Desiccant                          _____gms.

(H)     Net Impinger Volume Gain                                   _____mls.

(I)     Net Wt. Gain of Gooch Crucible                             _____gms.

(J)     Net Wt. Gain of Chloroform Ether Extracts                  _____gms.

(K)     Net Wt. Gain of Remaining Impinger Solution                _____gms.

(L)     Total Sample Wt.                                           _____gms.

$$(L) = (F) + (I) + (J) + (K)$$

(M)     Total Water in Sample Gas                                  _____mls.

$$(M) = (G) + (H)$$

ORSAT

%$CO_2$ =     _____          %$O_2$ =     _____

%CO  =     _____          %$N_2$ =     _____

**NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION**
**BUREAU OF AIR POLLUTION CONTROL**
**TECHNICAL SERVICES SECTION**

**DERIVATION OF ISOKINETIC SAMPLING RATE FORUMLA**

NOMENCLATURE:  (SEE APPENDIX 6)

DERIVATION:

1.  Isokinetic Sampling $= \dfrac{Un}{Us} \times 100\%$

2.  $Un$ (ft./ sec.) $= \dfrac{Vt \text{ (cu. ft.)}}{An \text{ (sq. ft.) x } t \text{ (min.) x } 60 \text{ (sec./min.)}}$

3.  $An$ (sq. ft.) $= \dfrac{A \times (Dn)^2 \text{ (sq. in.)}}{4 \times 144 \text{ (sq. in./sq. ft.)}} = 0.005454 \, (Dn)^2$

    Substitute 3 for An in 2 to obtain 4

4.  $Un = \dfrac{Vt}{0.005454 \, (Dn)^2 \text{ x } t \text{ x } 60} = \dfrac{3.0558 \, Vt}{(Dn)^2 \text{ x } t}$

5.  $Vt = \dfrac{Vm \text{ x } (Ts + 460) \text{ x } (Pb + \Delta H/13.6)}{(Tm + 460) \text{ x } (1\text{-}Q) \text{ x } Ps}$

    Substitute 5 for Vt in 4 to obtain 6.

6.  $Un = \dfrac{3.0558 \text{ x } Vm \text{ x } (Ts + 460) \text{ x } (Pb + \Delta H/13.6)}{(Dn)^2 \text{ x } (Tm + 460) \text{ x } (1\text{-}Q) \text{ x } t \text{ x } Ps}$

    Substitute 6 for Un in 1 to obtain 7

7.  %Isokinetic Sampling $= \dfrac{3.0558 \text{ x } Vm \text{ x } (Ts + 460) \text{ x } 100 \, (Pb + \Delta H/13.6)}{(Dn)^2 \text{ x } (Tm + 460) \text{ x } (1\text{-}Q) \text{ x } t \text{ x } Us \text{ x } Ps}$

    $= \dfrac{305.58 \text{ x } Vm \text{ x } (Ts + 460) \text{ x } (Pb + \Delta H/13.6)}{(Dn)^2 \text{ x } (Tm + 460) \text{ x } (1\text{-}Q) \text{ x } t \text{ x } Us \text{ x } Ps}$

# NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
## BUREAU OF AIR POLLUTION CONTROL
## TECHNICAL SERVICES SECTION

## % ISOKINETIC SAMPLING CALCULATIONS

| COMPANY | |
|---|---|
| STREET | |
| CITY | |
| STACK | |
| NJ NO. | INLET          OUTLET |

| FIELD & LAB. DATA | RUN 1 | RUN 2 | RUN3 | RUN 4 | RUN 5 |
|---|---|---|---|---|---|
| DATE | | | | | |
| $T_s$ ($^o$F) (Avg.) | | | | | |
| $V_m$ (CF) Avg.) | | | | | |
| $T_m$ ($^o$F) | | | | | |
| $D_n$ (inches) | | | | | |
| t (minutes) | | | | | |
| Q (decimal fraction) | | | | | |
| âs (ft./sec.) | | | | | |
| % Isokinetic Sampling | | | | | |

CALCULATIONS BY:_____

DATE:_____

**NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION**
**BUREAU OF AIR POLLUTION CONTROL**
**TECHNICAL SERVICES SECTION**

<u>DERIVATION OF EMISSION RATE FORMULA</u>

<u>NOMENCLATURE:</u>     (SEE APPENDIX 9)

<u>DERIVATION:</u>

1. $E \text{ (lbs/hr)} = G \dfrac{\text{(grs.)}}{\text{(cu. ft.)}} \quad \text{x} \quad Vo \dfrac{\text{(cu.ft.)}}{\text{(min.)}} \quad \text{x} \quad 60 \dfrac{\text{(min.)}}{\text{(hr.)}} \quad \text{x} \quad \dfrac{\text{lb.}}{7000 \text{ grs.}}$

   To convert from grams to grains (per cubic foot):

2. $G = wt \text{ (gms.) x} \quad \dfrac{1}{Vt \text{(cu. ft.)}} \quad \text{x} \quad 15.43 \dfrac{\text{(grs.)}}{\text{(gm.)}}$

3. $Vo = A \text{ (sq. ft.) x } Us \dfrac{\text{(ft.)}}{\text{(sec.)}} \quad \text{x} \quad 60 \dfrac{\text{(sec.)}}{\text{(min.)}}$

   Where,

   $Us = 2.9 \ Cp \sqrt{\Delta P \ (Ts+460) \ \text{x} \ \dfrac{1}{Gd} \ \text{x} \ \dfrac{29.92}{Ps}}$

   Substitute 2 for G and 3 for Vo in 1 to obtain 4:

4. $E = \dfrac{60}{7000} \quad \text{X } 15.43 \text{ x } 60 \text{ x } \dfrac{Wt}{Vt} \text{ x A x } Us = 7.9354 \dfrac{Wt}{Vt} \text{ x A x } Us$

5. $A \text{ (sq. ft.)} = \dfrac{A \text{ x } D^2 \text{ (sq. in)}}{4 \text{ x } 144 \ \dfrac{\text{(sq. in.)}}{\text{(sq. ft.)}}} = 0.005454 \ D^2$

   Substitute 5 for A in 4 to obtain 6:

6. $E = 0.04328 \ \dfrac{Wt}{Vt} \text{ x } D^2 \text{ x } Us$

   To convert meter conditions to flue conditions

7. $Vt = Vm \text{ (cu. ft.) x } \dfrac{(Ts + 460)}{(Tm + 460)} \quad \text{x} \quad \dfrac{1}{(1-Q)} \quad \text{x} \quad \dfrac{(Pb + \Delta H/13.6)}{Ps}$

   Substitute 7 for Vt in 6 to obtain 8:

8. $E = \dfrac{0.04328 \text{ x } Wt \text{ x } D_2 \text{ x } Us \text{ X } (Tm + 460) \text{ x } (1-Q) \text{ x } Ps}{Vm \text{ x } (Ts + 460) \text{ x } (Pb + \Delta H/13.6)}$

**NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION**
**BUREAU OF AIR POLLUTION CONTROL**
**TECHNICAL SERVICES SECTION**

EMISSION CALCULATION REPORT

| COMPANY | |
|---|---|
| STREET | |
| CITY | |
| STACK | |
| NJ NO. | INLET          OUTLET |

| FIELD & LAB DATA | RUN 1 | RUN 2 | RUN 3 | RUN 4 | RUN 5 |
|---|---|---|---|---|---|
| DATE | | | | | |
| Tm ($^o$F) (Avg.) | | | | | |
| Ts ($^o$F) (Avg.) | | | | | |
| $\Delta$P (inches water) | | | | | |
| D (inches) | | | | | |
| Wt (grams) | | | | | |
| Q (decimal fraction) | | | | | |
| Vm (cubic feet) | | | | | |
| E (LB/HR) (TOTAL) | | | | | |
| ALLOWABLE EMISSIONS (LBS/HR) BASED UPON POTENTIAL EMISSION RATE | | | | | |
| ALLOWABLE EMISSIONS (LBS/HR) BASED UPON SOURCE GAS EMITTED | | | | | |
| HEAT INPUT RATE (MILLIONS OF BTU/HR) | | | | | |
| MAXIMUM ALLOWABLE EMISSSION RATE (LB/HR) | | | | | |

CALCULATIONS BY:_____

DATE:_____

**APPENDIX 5**

**DETERMINATION OF EMISSION CONCENTRATION**
**AS GRAINS/DSCF CORRECTED TO 12% CO$_2$**
**MINUS CONTRIBUTION OF CO$_2$ FROM AUXILIARY FUEL**

1.      Emission Concentration (Cs) for a Test Run is Calculated by the Formulas:

Grains = Total Sample Weight (grams) x 15.43

$$V_m std = V_m \times \frac{530}{29.92} \times \frac{Ps}{(Tm + 460)}$$

Where,

$$Ps = Pb + \frac{Pstatic}{13.6}$$

$$Cs = \frac{Total\ Grains\ Sampled}{V_m std}$$

2.      Emission Concentration Corrected to 12% CO$_2$ Minus Auxiliary Fuel is Calculated by:

$$Cs_{12\%CO_2} = Cs \times \frac{12}{\%CO_2\ measured\ -\ \%CO_2\ contributed\ by}$$

in stack                auxiliary fuel

**APPENDIX 5A**

**DETERMINATION OF EMISSION CONCENTRATION**
**AS GRAINS/DSCF CORRECTED TO 7% $O_2$**

$$Cs_{7\%O_2} = Cs \times \frac{14}{\%O_2 \text{ in air} - \%O_2 \text{ measured in stack}}$$

Where,

Cs = Concentration in stack as grains/dscf

$\%O_2$ in air = 21

# APPENDIX 6

## CALCULATIONS FOR DETERMINATION OF MOISTURE CONTENT, GAS DENSITY AND MOLECULAR WEIGHT OF THE STACK GAS

1.      Percent Moisture by Volume in Stack Gas is Determined by the Formula:

$$\% \ \text{moisture} = \frac{Vv}{Vv + Vm} \ \text{x} \ 100$$

      Where,

$$Vv = .00267 \ \text{x} \ Vm \ \text{x} \ \frac{(Tm + 460)}{(Pb + \Delta H/13.6)}$$

2.      The Specific Gravity of the Flue Gas (Gd) equals the Ratio of the Molecular Weight of the Stack Gas to the Molecular Weight of Air (28.95).

$$Gd = \frac{Ms}{28.95}$$

3.      Molecular Weight of the Stack Gas is Calculated from Orsat Data and Moisture Content by the Formula:

$$Ms = (1\text{-}Q) \ \text{x} \ [(44 \ \text{x} \ \%CO_2{}^*) + (28 \ \text{x} \ \%CO^*) + (32 \ \text{x} \ \%O_2) + (28 \ \text{x} \ \%N_2{}^*)] + (18 \ \text{x} \ Q)$$

      *Percent expressed as decimal fraction.

**APPENDIX 7**

**NEW JESRSEY DEPARMENT OF ENVIRONMENTAL PROTECTION**
**BUREAU OF AIR POLLUTION CONTROL**
**TECHNICAL SERVICES SECTION**

## PRELIMINARY STACK TEST DATA

| | |
|---|---|
| COMPANY: | SUBCHAPTER: |
| STREET: | CITY: |
| DATA COLLECTED BY: | DATE: / / |
| EQUIVALENT STACK DIAMETER (in.): | DRY BULB TEMPERATURE: |
| HYDRAULIC DIAMETER (in.): | WET BULB TEMPERATURE: |
| DIAMETERS DOWNSTREAM: | ESTIMATED MOISTURE: |
| DIAMETERS UPSTREAM: | ACTUAL STACK TEMPERATURE: |
| SAMPLING POINTS NEEDED: | STATIC PRESSURE: |
| ORIFICE: I.D.# $\Delta H@$: | MINIMUM $\Delta P$: |
| PITOT: I.D.# Cp: | MAXIMUM $\Delta P$: |
| NOZZLE: I.D.# DIAM: | AVG. $\Delta P$: |
| METER: I.D.# Y-FACTOR: | ESTIMATED METER TEMP.: |

| POINT NO. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
|---|---|---|---|---|---|---|---|---|
| DIST. (in.) | | | | | | | | |
| POINT NO. | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
| DIST. (in.) | | | | | | | | |
| POINT NO. | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 |
| DIST. (in.) | | | | | | | | |

MANHOURS                    COUPLING:_____

REVIEWED BY:_____

DATE:_____

**NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION**
**BUREAU OF AIR POLLUTION CONTROL**
**TECHNICAL SERVICES SECTION**

**FIELD DATA SHEET**

| DATE: / / | RUN: | INLET | OUTLET |
|---|---|---|---|
| COMPANY: | | | |
| STACK: | NJ NO. | | |
| DESICCANT: IMPINGER: MLS.: FILTER #: | | | |
| TEST STARTED: (AM) (PM) TEST FINISHED: (AM) (PM) | | | |
| ACTUAL SAMPLING TIME: MLS. COLLECTED: NOZZLE DIAM. (in.) | | | |

| PORT | POINT | ΔP | ΔH | METER TEMP. | | | $T_1$ | $T_2$ | PUMP | REMARKS |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | IN | OUT | AVG. | | | | |
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| AVG. | | | | | | | | | | |

Meter Date:
  Final Vol. (CF):_____      Pb inches Hg:_____
  Initial Vol. (CF):_____      Pst inches $H_2O$:_____
        Volume:_____
  Corrected Volume:_____      Tested By:_____
  Pretest Leak Check_____ft$^3$ @ 15  inches
  Pretest Leak Check_____ft$^3$ @ ___ inches

**APPENDIX 8**

**NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION**
**BUREAU OF AIR POLLUTION CONTROL**
**TECHNICAL SERVICES SECTION**

**FUEL OIL LAB ANALYSIS AND STOICHIOMETRIC CALCULATION OF CO2 FROM FUEL**

COMPANY:_____

LOCATION:_____

STACK:_____N.J. NO.:_____

DATE:_____RUN NO.:_____

FUEL TYPE:_____AMOUNT OF FUEL USED:_____

PERCENT CARBON (BY WEIGHT):_____DSCFM (STACK):_____

DENSITY:_____

Calculations

Liquid Fuel:

$$\frac{Gal.}{Min.} \times \frac{Lb.}{Gal.} \times \%C^* \times \frac{387\ DSCF\ CO_2}{12\ Lb.\ C} = DSCFM\ CO_2\ From\ Fuel$$

Solid Fuel:

$$\frac{Lb.}{Min.} \times \%C^* \times \frac{387\ DSCF\ CO_2}{12\ Lb.\ C} = DSCFM\ CO_2\ From\ Fuel$$

Gaseous Fuel:

$$\frac{SCF}{Min.} \times \frac{Lb.\ C}{SCF}\ \%C^* \times \frac{387\ DSCF\ CO_2}{12\ Lb.\ C} = DSCFM\ CO_2\ From\ Fuel$$

% $CO_2$ From Fuel:

$$\frac{DSCFM\ CO_2\ From\ Fuel}{DSFM\ in\ Stack} \times 100 = \%CO_2\ Contributed\ from\ Fuel$$

*Percent Expressed as Decimal Fraction

**NEW JERSEY DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF AIR POLLUTION CONTROL
TECHNICAL SERVICES SECTION**

<u>NOMENCLATURE</u>

A = Internal cross sectional area of flue at sampling location expressed in square feet.

ACFM = Actual cubic feet per minute at stack conditions of temperature and pressure.

An = Cross sectional area of sampling nozzle orifice expressed in square feet.

CF = Cubic feet.

CFM = Cubic feet per minute.

Cp = Pitot tube correction factor

Cs = Concentration in stack gas defined as grains/dscf

D = Internal diameter of flue in inches

Dn = Internal diameter of sampling nozzle in inches.

DSCF = Dry standard cubic foot

E = Emission rate in pounds per hour

fps = Velocity in feet per second.

G = Particulate concentration in grains per cubic feet.

Gd = Specific gravity of flue gas referred to that of air at flue gas temperature and pressure.

$\Delta H$ = Orifice draft gauge reading in equivalent inches of water.

Ms = Molecular weight of stack gas (wet basis)

mg = Milligram

ml = Milliliter

mm Hg = Millimeter of mercury

$\Delta P$ = Velocity head draft gauge reading in equivalent inches of water.

$\overline{\Delta P}$ = Root mean square value of differential pressures of all traverse points in the stack (inches of water)

Pb = Barometric pressure in inches of mercury absolute

Pm = Absolute pressure at meter in inches of mercury.

Ps = Absolute pressure in flue, derived by the algebraic sum of barometric and static pressures and expressed in inches of mercury.

Pst = Static pressure in flue expressed in inches of mercury gauge.

psia = Pounds per square inch absolute

Q = Moisture in flue gas (decimal fraction by volume)

SCFM = Cubic feet per minute at 70°F and one atmosphere pressure (14.7 psia or 760 mm Hg) or standard cubic feet per minute.

t = Duration of sampling time in minutes

Tm = Temperature at meter in degrees F

Ts = Flue gas temperature in degrees F

Un = Sample nozzle gas velocity in feet per second

Us = Flue gas velocity at the point where measured in feet per second

âs = Average flue gas velocity for a test run

Vm = Total volume of gas sampled as measured by meter in cubic feet

VmSTD = Total volume of gas sampled at standard conditions.

Vo = Volume rate of flue gas in cubic feet per minute

Vt = Total volume of gas sampled in cubic feet and converted to flue conditions

Vv = Total volume of water in sample gas in cubic feet converted to meter conditions (vapor state)

Vw = Total volume of water in sample gas in cubic centimeters (condensate plus water adsorbed in desiccant)

Wt = Weight of particulate sample collected in grams