

The Anatomy of a RATA

Overview

Relative Accuracy Test Audit, or “RATA”, is a test method required by Title 40 of the Code of Federal Regulations (CFR). The test requirements for Continuous Emissions Monitoring Systems (CEMS) are covered under Part 60 and/or Part 75. A plant’s air permit describes what is to be tested and any specific test requirements. X`

The RATA testing is used for one or more of the following reasons:

- a) Initial certification of a CEMS
- b) Annual CEMS Testing Requirement
- c) Relocation of CEMS Probe(s)
- d) Replacement of CEMS Analyzers or other Major System Components
- e) Certain CEMS System Repairs (typically applies to clients operating under Part 75)

A RATA test is used to determine the accuracy of an installed CEMS and/or Flow Monitoring system. If the testing passes, then all recorded data is considered “Valid” for reporting emissions to the EPA. If the system fails the testing, then the data is “NOT Valid” for reporting. To return a system’s reporting status to “Valid” after a failure, the system must be retested and pass.

A RATA test is a comparison of a CEMS recorded readings against an independent testing company’s reading. The testing company has their own CEMS (probes, umbilical’s, analyzers, and other required equipment) typically in a trailer that they park close to the stack or duct where the CEMS is installed. They insert their probe into the stack (or duct) in a test port close to the installed CEMS port.

The stack test company CEMS is considered the “standard” for measurement and comparison. What makes it the standard is simply the calibration of it against EPA Protocol Gases.

The independent test company readings are compared with the CEMS readings to determine the accuracy of the CEMS. If the difference, stated in “percent of error”¹, are within the applicable regulation limits, then the test has passed. If one or more of the compared readings fail, then the CEMS readings are considered invalid for that portion of the test that failed.

¹ Diluents (O₂ & CO₂) may use “absolute difference” instead of “percent of error”.

RATA testing is ONLY for gases and flow monitors, Opacity is NOT covered under RATA testing.

NOTE: There are tests known as Particulate Tests, however, they are not covered here.

Part 60 vs. Part 75

Required RATA testing differs between Part 60 and Part 75 (again, the plant’s air permit designates the specific testing requirements). RATA requirements can be affected by State requirements as well. For instance, Pennsylvania sites generally operate under “tighter restrictions” as governed by the Pennsylvania Department of Environmental Protection (PADEP). Sites that are Part 60 in that state may have to comply with the Part 75 rules.

- a) **For Part 60 applications:**

- i) One RATA test per year is required. Error limits are typically 20% for gases and 10% for flow monitors.

NOTE: An air permit may designate a different “percent of allowable error” due to operational limitations. This is referred to as the “Applicable Standard”.

- ii) The RATA test is typically the same quarter every year and is usually in the same quarter as the original system certification.
- iii) In the quarter that a RATA test is performed, a Cylinder Gas Audit (CGA) is not required. (i.e. the RATA test supercedes the CGA for that quarter).

NOTE:

- a) Some sites may require a CGA in the quarter that the RATA is performed due to their “approved” QA/QC procedures.
- b) Individual states can also request a CGA be completed along with the RATA. The state EPA can be more restrictive than the CFR’s, but never less restrictive.
- iv) Maintenance performed on a CEMS does not require a RATA or CGA. However, even though it is not required, it is good practice to run the CGA gases to check for errors after any repairs.

b) For Part 75 applications:

- i) Error limits during testing are more restrictive - or - “tighter” for Part 75 operators as compared to Part 60 operators. For gases, one RATA test per year is required - ONLY if the error is less than 7.5 %. Two RATA tests per year are required if the error is greater than 7.5 %, but less than 10 %. The RATA is considered “Failed” if the error exceeds 10%. For Flow Monitors, the error limit is 10%.
- ii) The RATA test is typically the same quarter every year but may vary if a second test is required.
- iii) When a RATA test is performed, the Linearity Audit for that quarter is still required.
- iv) Certain maintenance performed on the system may require a RATA, or just a Linearity. These maintenance/testing requirements are typically found in a sites QA/QC manual.

Test Methods

The regulations have different methods for testing various gases and/or flow systems. The plants air permit usually designates which test method is to be used. The most typical Methods are called “Analyzer Methods”. There is a specific Method for each gas. Here is a list of the most popular Methods with a link to the EPA Method Description:

Method Number	Gas/Parameter	Link
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Methods 1-4	All four required for “Flow” 1 – Sample/Velocity Traverses 2 – Velocity S-Type Pitot 3A – Oxygen & Carbon Dioxide 4 – Moisture Content	EPA Test Method 1 EPA Test Method 2 EPA Test Method 3A EPA Test Method 4
Method 3A	Oxygen & Carbon Dioxide	EPA Test Method 3A
Method 6C	SO ₂	EPA Test Method 6C
Method 7E	NO _x	EPA Test Method 7E
Method 10	CO	EPA Test Method 10
Method 25A	Hydrocarbons (THC)	EPA Test Method 25A
Method 30B	Mercury (sorber trap)	EPA Test Method 30B
Method 321	HCl	EPA Test Method 321

Parameters & Test Runs

The most common protocols, or “test parameters” are as follows:

- a) Raw channels - NO_x, SO₂, CO, THC, O₂ & CO₂.
- b) Calculated Channels - NO_x lbs./MMBtu, NO_x lbs./hr., SO₂ lbs./MMBtu, SO₂ lbs./hr., CO lbs./MMBtu, CO lbs./hr., NO_x corrected to (X)% of O₂, CO corrected to (X)% of O₂.
- c) Stack Flow Rate - Normally stack flow is read in KSCFM (1000 Standard Cubic Feet per Minute). It is typically determined by a flow monitor which uses a probe and a monitoring/calibration unit in a cabinet. In some cases, the stack flow rate can be determined by the fuel flow rate and the type of fuel being used in a boiler. These two numbers will give what is called “Total Heat”.

Summary of the test runs:

- a) Testing can be started once the boiler/source under test is stabilized - and - above 50% of its load capacity.
- b) The test is comprised of a minimum of 9 runs, with a maximum of 12 runs. Each run is 21 minutes long and consists of the averaged readings obtained during that run. (i.e. 9:00 - 9:20 = 21 minutes)
- c) Error limits for the *first two runs* are very critical. If the percentage of error is out of limits in either, or both, of the first two runs, RATA testing can be aborted to determine the cause of the error. Once the problem is corrected, the testing can start over. If the error limit is close, but not over, there is a chance that as the testing continues, it fails. Determination of whether to continue is important here.

- d) If any one of the testing protocols during a run exceeds the limit, as reported in “percent of error”, then that protocol “Fails”.

NOTE: The regulations do allow up to 3 additional runs to be performed. If an additional run(s) passes, then the data from those additional runs can be substituted in for a “Failed” run. However, the Stack Crew is required to submit the “failed” runs and denote which “Passed” data is being substituted in. **A total of 9 “Passing” runs must be completed in order to consider that the RATA has passed.**

Definitions

- CEMS - Continuous Emission Monitoring System
- RATA testing - also known as “Stack Testing” or “Source Testing”.
- Independent test companies - also known as “Stack Crews”.
- Preliminary Runs - these are “unofficial” runs typically done the day before the actual RATA starts. They are done after the Stack Crew gets set up and will give an indication of any potential issues prior to the “official” start of the RATA testing.
- ppm - Parts Per Million
- Diluent - For CEMS purposes, a gas that reduces the concentration of a pollutant gas.
- SCF - Standard Cubic Feet. Normally used for volumetric flow rates. (i.e. 1,000 Standard Cubic Feet per Minute would be shown as KSCFM)
- Protocols - these are the required testing parameters (i.e. NO_x ppm, O₂%, lbs./MMBtu...etc.).
- Applicable Standard (or Emission Standard) - The emission limit designated in the sites permit for that protocol.
- RM (Reference Method) - The Stack Crews “final” reading after being corrected for moisture, bias check... etc.
- RAW (or “uncorrected”) channels - these are the readings directly from the analyzers.
- Calculated Channels - these are the Raw readings along with other signal inputs which are calculated through formula’s. (i.e. NO_x - lbs./MMBtu, CO - lbs./hr., NO_x - Corrected for 3% O₂ ... etc.)
- Pollutant - Gases monitored. (i.e. NO_x, SO₂, CO & THC)
- Diluents - Gases that can reduce or alter the pollutant levels. (i.e. O₂ & CO₂)

Error Limits & Regulation References

NOTE: References are based on the 2012 CFRs. RATA test procedures are as follows:

- a) NO_x & SO₂ (40CFR60 App. B, PS2 - 8.4) *** Number of runs are found in 8.4.4
- b) CO (40CFR60 App. B, PS4A - 8.4) *** In 8.1, the number of runs are the same as NO_x.
- c) O₂ & CO₂ (40CFR60 App. B, PS3 - 8.4) *** In 8.1, the number of runs are the same as NO_x.

“Absolute difference” refers to the actual difference between the CEMS monitor & the Reference Method. (i.e. The CEMS system SO₂ reads an average value of 57ppm and the Stack Crew reads an average value of 67ppm. The absolute difference is 10ppm)

Part 60

- 1) NO_x ppm - 40CFR60 Appendix B, PS2 - 13.2
 - 20% error limit using “RM” as long as the stack emissions are greater than 50% of the Applicable Standard.
 - 10% error limit using Applicable Standard as long as the stack emissions are less than 50% of the Applicable Standard.
- 2) NO_x (*lbs./MMBtu*) - 40CFR60 Appendix B, PS2 - 13.2
 - Error limits are the same as above.
- 3) SO₂ ppm - 40CFR60 Appendix B, PS2 - 13.2
 - 20% error limit using “RM” as long as the stack emissions are greater than 50% of the Applicable Standard.
 - 10% error limit using Applicable Standard as long as the stack emissions are less than 50% of the Applicable Standard.
- 4) SO₂ (*lbs./MMBtu*) - 40CFR60 Appendix B, PS2 - 13.2
 - 20% of the Applicable Standard as long as the Applicable Standard is less than 0.20 *lbs./MMBtu*.
 - 15% of the Applicable Standard as long as the Applicable Standard is 0.30 *lbs./MMBtu* to and including 0.20 *lbs./MMBtu*.
- 5) CO ppm - 40CFR60 Appendix B, PS4 - 13.2 (and PS4A - 13.2)
 - 10% error limit using Reference Method (RM).
 - 5% error limit using Applicable Standard.
 - Or within 5 ppmv absolute average difference plus 2.5% Confidence Coefficient.
- 6) CO (*lbs./MMBtu*) - (not specified in the regulations)
 - Error limits are the same as the CO ppm.
- 7) CO₂ & O₂ - 40CFR60 Appendix B, PS3 - 13.2
 - 1.0% Absolute Difference.
- 8) Flow - Reference the section below; as Flow is regulated by Part 75.

Part 75

- 1) NO_x ppm ONLY (used with flow monitoring for determining mass emission) - 40CFR75 Appendix A - 3.3.7
 - 10% error limit
 - Or - If the average of the Reference Method is less than or equal to 250ppm, an absolute difference of ± 15 ppm.
- 2) NO_x PPM/ Diluent - 40CFR75 Appendix A - 3.3.2
 - 10% error limit
 - Or - If the average of the Reference Method is less than or equal to 250ppm, an absolute difference of ± 15 ppm is allowed.
- 3) NO_x (*lbs./MMBtu*) - 40CFR75 Appendix A - 3.3.2
 - Error limits are the same as the NO_x ppm.
 - Or - If the average of the Reference Method is less than or equal to 0.200 (*lbs./MMBtu*), an absolute difference of ± 0.020 (*lbs./MMBtu*) is allowed.
- 4) SO₂ - 40CFR75 Appendix A - 3.3.1
 - 10% error limit
 - Or - If the average of the Reference Method is less than or equal to 250ppm, an absolute difference of ± 15 ppm is allowed.
- 5) SO₂ (*lbs./MMBtu*) - 40CFR75 Appendix A - 3.3.1
 - Error limits are the same as the SO₂ ppm
- 6) CO ppm & CO (*lbs./MMBtu*) - Reference the section above; as CO is regulated by Part 60.
- 7) CO₂ & O₂ - 40CFR75 Appendix A - 3.3.3
 - 10% error limit
 - Or - if the absolute difference between the CEMS system and the Reference Method does not exceed ± 1.0 percent.
- 8) Flow - 40CFR75 Appendix A - 3.3.4
 - 10% error limit at any load - or - if flow rate is less than or equal to 10 fps (feet per second) an absolute difference of ± 2.0 fps (feet per second)

Common Formulas

1) RATA run quick check -

- To perform a quick check of a single RATA run, make sure the reading supplied by the Stack Crew has been corrected for the bias check and/or converted to dry (wet) as necessary.
- The formula below is for pollutants and flow readings (KSCFM). Errors for Diluents are the Absolute Difference after any corrections.

$$\%Error = \frac{CEMS\ Reading - Stack\ Crew\ Reading}{Stack\ Crew\ Reading} * 100$$

2) lbs./MMBtu - 40CFR60, Appendix A-7, Method 19 - 12.2 (- or - 40CFR75, Appendix F, 3.)

- The formula used, is based on whether the system is Dilution (WET) or Full Extractive (DRY) and the type of diluent being monitored (O₂ or CO₂).
- The formula's below show a "K" value. The "K" is not represented in the CFR listed equations but is inferred in the text of section 12.2. The "K" value converts the ppm reading (based on the type of gas being used) to lbs./scf.
- Some sites may have unique F - Factor number based on a non-standard type of fuel. (i.e. Different types of coal [Sub-Bituminous may be 1840])

a) Dry Pollutant & Dry O₂ (Full Extractive)

$$E = KC_d F_d \frac{20.9}{(20.9 - \%O_{2d})} \quad \text{(Equation 19-1)}$$

b) Wet Pollutant & Wet O₂ (Dilution)

$$E = KC_w F_w \frac{20.9}{[20.9(1 - B_{wa}) - \%O_{2w}]} \quad \text{(Equation 19-2)}$$

c) Dry Pollutant & Dry CO₂ (Full Extractive)

$$E = KC_d F_c \frac{100}{[\%CO_{2d}]} \quad \text{(Equation 19-6)}$$

d) Wet Pollutant & Wet CO₂ (Dilution)

$$E = KC_w F_c \frac{100}{[\%CO_{2w}]} \quad \text{(Equation 19-7)}$$

E	=	Pollutant emission rate in lbs/mmbtu
K	=	Conversion value from Table 19-1 below
C _d	=	Pollutant value in "ppm - Dry"
C _w	=	Pollutant value in "ppm - Wet"
F _c , F _d & F _w	=	F-Factor from Table 19-2 below "F _c " using dry or wet CO ₂ as a diluent "F _d " using dry O ₂ as a diluent "W" using wet O ₂ as a diluent
O _{2d} & CO _{2d}	=	O ₂ or CO ₂ concentration dry - value in percentage.
O _{2w} & CO _{2w}	=	O ₂ or CO ₂ concentration wet - value in percentage.
B _{wa}	=	Moisture content value for ambient air (default value = 0.027). Reference 40CFR60, Appendix A-7, Method 19, 12.2.2.1.1

The tables below are from 40CFR60, Appendix A-7, Method 19, 17.0. **NOTE:** The molecular weight formula is found in 40CFR 60.45.

TABLE 19-1—CONVERSION FACTORS FOR CONCENTRATION

From	To	Multiply by
g/scm	ng/scm	10 ⁹
mg/scm	ng/scm	10 ⁶
lb/scf	ng/scm	1.602 × 10 ¹³
ppm SO ₂	ng/scm	2.66 × 10 ⁶
ppm NO _x	ng/scm	1.912 × 10 ⁶
ppm SO ₂	lb/scf	1.660 × 10 ⁻⁷
ppm NO _x	lb/scf	1.194 × 10 ⁻⁷

TABLE 19-2—F FACTORS FOR VARIOUS FUELS¹

Fuel Type	F _d		F _w		F _c	
	dscm/J	dscf/10 ⁶ Btu	wscm/J	wscf/10 ⁶ Btu	scm/J	scf/10 ⁶ Btu
Coal:						
Anthracite ²	2.71×10 ⁻⁷	10,100	2.83×10 ⁻⁷	10,540	0.530×10 ⁻⁷	1,970
Bituminous ²	2.63×10 ⁻⁷	9,780	2.86×10 ⁻⁷	10,640	0.484×10 ⁻⁷	1,800
Lignite	2.65×10 ⁻⁷	9,860	3.21×10 ⁻⁷	11,950	0.513×10 ⁻⁷	1,910
Oil ³	2.47×10 ⁻⁷	9,190	2.77×10 ⁻⁷	10,320	0.383×10 ⁻⁷	1,420
Gas:						
Natural	2.34×10 ⁻⁷	8,710	2.85×10 ⁻⁷	10,610	0.287×10 ⁻⁷	1,040
Propane	2.34×10 ⁻⁷	8,710	2.74×10 ⁻⁷	10,200	0.321×10 ⁻⁷	1,190
Butane	2.34×10 ⁻⁷	8,710	2.79×10 ⁻⁷	10,390	0.337×10 ⁻⁷	1,250
Wood	2.48×10 ⁻⁷	9,240	.....	.....	0.492×10 ⁻⁷	1,830
Wood Bark	2.58×10 ⁻⁷	9,600	.....	.....	0.516×10 ⁻⁷	1,920
Municipal	2.57×10 ⁻⁷	9,570	.....	.....	0.488×10 ⁻⁷	1,820
Solid Waste .....	.....	.....	.....	.....	.....	.....

¹ Determined at standard conditions: 20 °C (68 °F) and 760 mm Hg (29.92 in Hg)

² As classified according to ASTM D 388.

³ Crude, residual, or distillate.

EXAMPLE: Calculate the NO_x lbs./MMBtu on a Dilution system using equation 19-7:

- Fuel used is Natural Gas.
- NO_x reading is 35ppm
- CO₂ reading is 7.68%.

- Convert the NO_x ppm to lb/scf by multiplying the NO_x ppm (C_w) reading by 1.194*10⁻⁷ (K)
35 x 0.0000001194 = **0.0000041790** (result "A")
- Multiply result "A" with the (F_c) factor for Natural Gas. **NOTE:** scf/10⁶ Btu = scf/MMBtu
0.0000041790 x 1040 = **0.00434616** (result "B")
- Divide 100 by the CO₂ reading (CO_{2w})
100 ÷ 7.68 = **13.02083333** (result "C")
- Multiply result "B" with result "C".
0.00434616 x 13.02083333 = **0.056590625 lbs./MMBtu**

3) lbs./hr. - 40CFR75, Appendix F

- The formula used below, is based on whether the system is Dilution (WET) or Full Extractive (DRY) and how the mass emissions rate is determined (flow monitor - or - heat input).
- Flow readings from Flow Monitors are ALWAYS considered “WET”.

a) Dilution (WET) using Flow Monitor (WET) - 40CFR75, Appendix F, 2.1

$$E_h = K C_h Q_h \quad (\text{Equation F-1})$$

b) Full Extractive (DRY) using Flow Monitor (WET) - 40CFR75, Appendix F, 2.2

$$E_h = K C_{hp} Q_{hs} \frac{(100 - \%H_2O)}{100} \quad (\text{Equation F-2})$$

c) Full Extractive (DRY) - or - Dilution (WET) using Heat Input - 40CFR75, Appendix F, 7. -or- 8.

$$E_h = (ER)(HI) \quad (\text{Equation F-23 / F-24 / F-24a})$$

E_h	=	Hourly mass emission rate during operation (lbs/hr).
K	=	Conversion value from Table 19-1 above.
C_h	=	Hourly average pollutant value in PPM - WET.
C_{hp}	=	Hourly average pollutant value in PPM - DRY.
Q_h & Q_{hs}	=	Hourly average volumetric flow rate during operation in scfh - WET.
$\%H_2O$	=	Hourly average stack moisture content (percent by volume).
ER	=	Hourly average pollutant rate in “lbs/mmbtu”.
HI	=	Hourly average Heat Input rate in “mmbtu/hr”.

- NOx = Appendix E, 3.3
- SO₂ = Appendix D, 3.3.2 & Appendix F, 2.0

4) Flow - 40CFR60, Appendix A1, Method 2

- The most commonly used formula is shown below and is broken down even further to show the individual calculations as listed in the regulations and to show the CEMDAS formula reference numbers.

$$VF = UC \times 0.06 \times 85.49 \times C_p \times \sqrt{\Delta P} \times \sqrt{\frac{T_s + 460}{P_s + M_s}} \times A \times 17.647 \times \frac{P_s}{T_{s(abs)}}$$

1	2	3	4	5	6	7	8	9
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- 1) VF = Volumetric Flow in KSCFM (1000 Standard Cubic Feet per Minute)
- 2) UC = Unit Conversion (if applicable - but not normally used)
- 3) Conversion number = This number converts the stack gas velocity from standard cubic feet per second to 1000 standard cubic feet per minute. 60 seconds in a minute divided by 1000 = 0.06.

Blocks 4 - 7 below determine the average stack gas velocity (* V_s)

(Found in 40CFR60, Appendix A1, Method 2, Equation 2-7)

- 4) Conversion number = “English” velocity equation constant which is referred to as * K_p converts the results into (feet per sec).

(This number is found in 40CFR60, Appendix A1, Method 2 just after Equation 2-7)

- 5) * C_p = Pitot Tube Coefficient - or EPA Constant (typically 0.84)
6) * ΔP = Delta P - or DP - or Differential Pressure (in inches of Water Column (H₂O))

(This number is found in 40CFR60, Appendix A1, Method 2 just after Equation 2-7)

- 7) * T_s = Actual stack temperature in degrees Fahrenheit (°F).

* $T_{s(abs)}$ = By adding 460 to * T_s , the temperature is now in degrees Rank (°R)

* P_s = Current stack static pressure - in inches of Mercury (in. Hg)

* M_s = Current molecular weight of stack gas (Wet basis)

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- 8) * A = Cross-sectional Area of stack in square feet (ft²)

- 9) Section of Volumetric Flow Rate Formula from 40CFR60, Appendix A1, Method 2 (Equation 2-8)

a) Formula is converted from $\frac{T_{std} \times P_s}{T_{s(abs)} \times P_{std}}$ to $\left(\frac{T_{std}}{P_{std}}\right) \times \left(\frac{P_s}{T_{s(abs)}}\right)$

b) If * $T_{std} = 528$ (°R) and * $P_{std} = 29.92$ (in. Hg) then the formula becomes $\left(\frac{528}{29.92}\right) \times \left(\frac{P_s}{T_{s(abs)}}\right)$ which is equivalent to $17.647 \times \left(\frac{P_s}{T_{s(abs)}}\right)$

* 40CFR60, Appendix A1, Method 2 (section 12.1 Nomenclature)

- Flow is always considered WET. When using a Full Extractive system, the sample is DRY. Convert the “WET” KSCFM to “DRY” by subtracting the stack moisture, in %, from 100, then divide that result by 100. Now multiply that value by the WET KSCFM. (i.e. 15% moisture would be shown as $((100-15) \div 100)$ which equals 0.85)