CIBO Technical Focus Group 12/8/2015

Compliance Concerns with Monitoring Data and Emissions Calculations

Joseph Macak

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Having a permit is one thing … living with it is another!

Compliance data must be accurate, complete, and readily available.

Are your facilities paying attention to the data sources? Maintenance records?

Discussion

- Discuss EPA Access to Data
- Data Concerns and Quality
- Data Accuracy
- Permitting for Uncertainty

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Construction and Operating Permits

- EPA (federal, state agencies) want permit conditions that force facilities to demonstrate continuous emissions compliance.
  - Emissions monitoring
  - Emissions calculations
  - Plant operating data (fuel flow, steam production, etc.)
  - Control equipment operations
- Facility "Responsible Official" must sign off on data validity and compliance status.
  - Do they know what they are signing? Proper due diligence of the reports?

Sometimes the permit conditions make no sense, and nobody objects to them in an effort to get the permit issued.

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Unintended Consequences

- If you "mess up" … other facilities will be affected!
  - Inspectors finds a problem(s) with data quality and recordkeeping … leads to content for weekly agency compliance calls … information shared with EPA regional offices … becomes a part of a hit list for things to look at for other similar facilities.
- EPA Section 114 letters end up affecting other sites.

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Compliance at Energy Facilities

- Regulators more much more knowledgeable of permit requirements and ongoing obligations for facilities.
  - Site inspections are no longer a slam dunk
  - Looking at specific permit conditions and facility methodology for demonstration of compliance.
  - Cannot rely on one person at the site cognizant with permit requirements
  - Where is all the data to demonstrate compliance?
  - Is the data accurate?

The Dreaded "Section 114" Letter

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 5

IN THE MATTER OF:

[redacted]

ATTENTION:

[redacted]
Plant Manager

Regional letter going after data at other similar facilities.

<u>Request to Provide Information Pursuant to the Clean Air Act</u>

The U.S. Environmental Protection Agency is requiring [redacted] or you) to submit certain information about the facility at [redacted] Appendix A provides the instructions needed to answer this information request, including instructions for electronic submissions. Appendix B specifies the information that you must submit. You must send this information to us within thirty (30) calendar days after you receive this request.

We are issuing this information request under Section 114(a) of the Clean Air Act (the CAA), 42 U.S.C. § 7414(a). Section 114(a) authorizes the Administrator of EPA to require the submission of information. The Administrator has delegated this authority to the Director of the Air and Radiation Division, Region 5.

[redacted] We are requesting this information to determine whether your emission source is complying with the Illinois State Implementation Plan and the Clean Air Act.

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How Easily Can You Comply With The Request?

[redacted] must submit all required information under an authorized signature with the following certification:

> I certify under penalty of law that I have examined and am familiar with the information in the enclosed documents, including all attachments. Based on my inquiry of those individuals with primary responsibility for obtaining the information, I certify that the statements and information are, to the best of my knowledge and belief, true and complete. I am aware that there are significant penalties for knowingly submitting false statements and information, including the possibility of fines or imprisonment pursuant to Section 113(c)(2) of the Clean Air Act and 18 U.S.C. §§ 1001 and 1341.

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How Easily Can You Comply With The Request?

We may use any information submitted in response to this request in an administrative, civil or criminal action.

Failure to comply fully with this information request may subject [redacted] to an enforcement action under Section 113 of the CAA, 42 U.S.C. § 7413.

You should direct any questions about this information request to [redacted] at [redacted]

4/15/14

Date

George T. Czerniak
Director
Air and Radiation Division

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How Easily Can You Comply With The Request?

11. Provide a detailed description (including efficiency) of the types of emission control equipment associated with [redacted] and processing equipment associated with the use of any raw material identified in response to Request #2. Include the installation date and the results of any initial performance testing or subsequent testing, if not included in response to Request #10.

12. Provide a copy of the manufacturer specifications for any emission control equipment listed by the company in response to Request #11. For the facility's thermal oxidizer, ensure that the manufacturer's minimum operating temperature and associated destruction efficiency is provided in your response. The response must also clearly identify the standard operating temperature at which the facility operates the thermal oxidizer.

13. From the time period January 1, 2009 to the present, provide hourly temperature records, in an Excel Workbook, for the thermal oxidizer.

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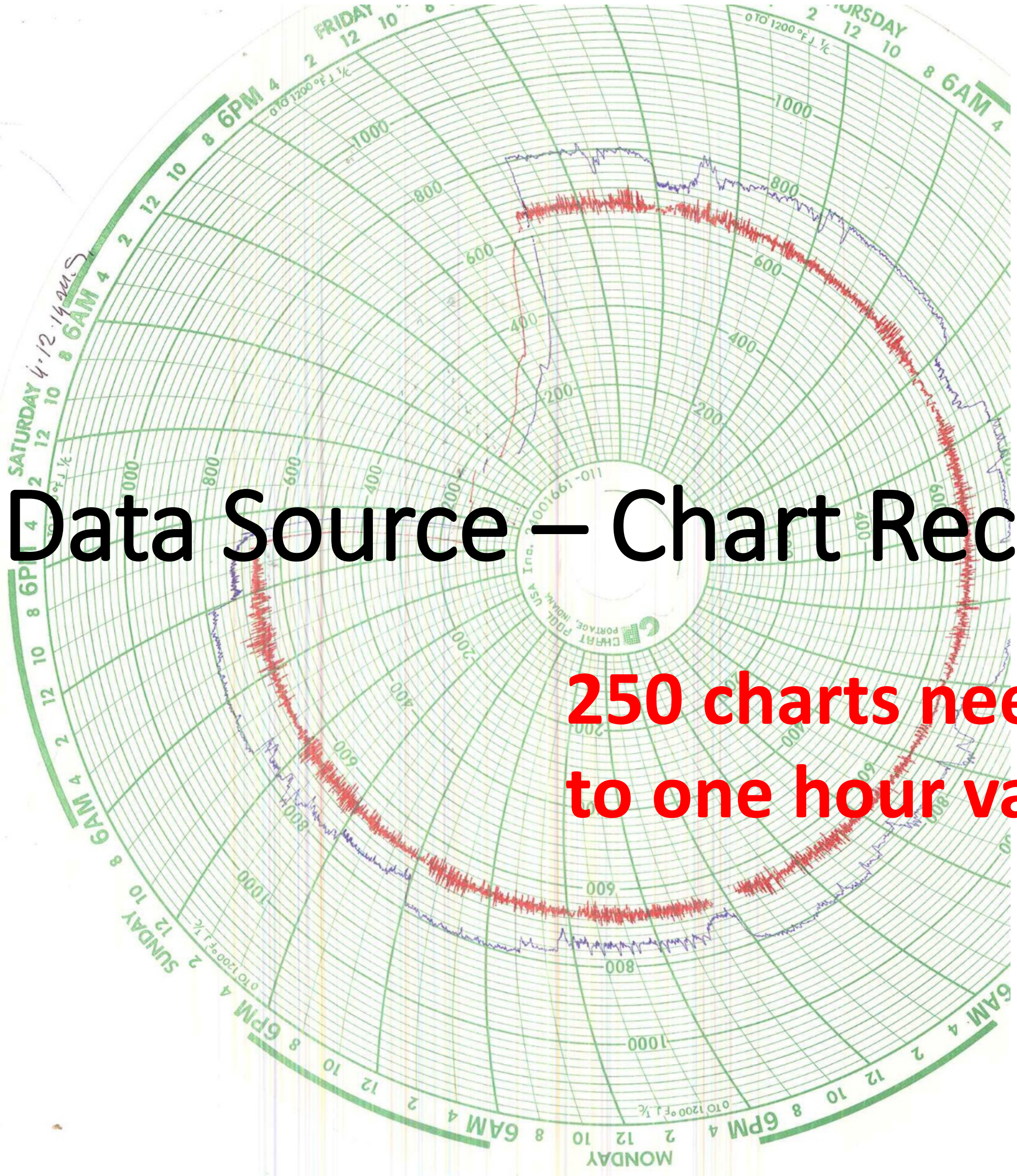
The Data Source – Chart Recorder



250 charts need to be converted to one hour values.

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How Easily Can You Comply With The Request?

- Data Quality
  - Missing charts in files
  - Illegible or “no ink” on plots
  - Data gaps
  - Undocumented excursions of temperature requirements
    - Who is looking at this?
- Manpower intensive to convert to EXCEL format
  - Accuracy of the manual conversion of continuous data to hourly values.

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Continuous Compliance Certifications

"With the possible exception of those permit terms and conditions identified below (referring to a list of deviations, exceedances and excursions), emission units described in permit # were in compliance with all permit terms and conditions over the previous year as determined by all required testing and monitoring in the permit and other material information."

Manual compliance records … >50% of time significant deficiencies in what is reported.
Continuous monitoring of compliance records … 5-10% (can be better)

Compliance at Energy Facilities
Computer Technology and Data Acquisition

- Coal going away … natural gas
  - Regulators are looking much closer (finding new things to go after)
- Computer technology … more data available for EPA
- Permit conditions requiring more continuous data and recordkeeping
  - Check validity of the site reporting and calculations
  - Rolling averages often in error (e.g. 30 day rolling average)

More Data … More to Go Wrong

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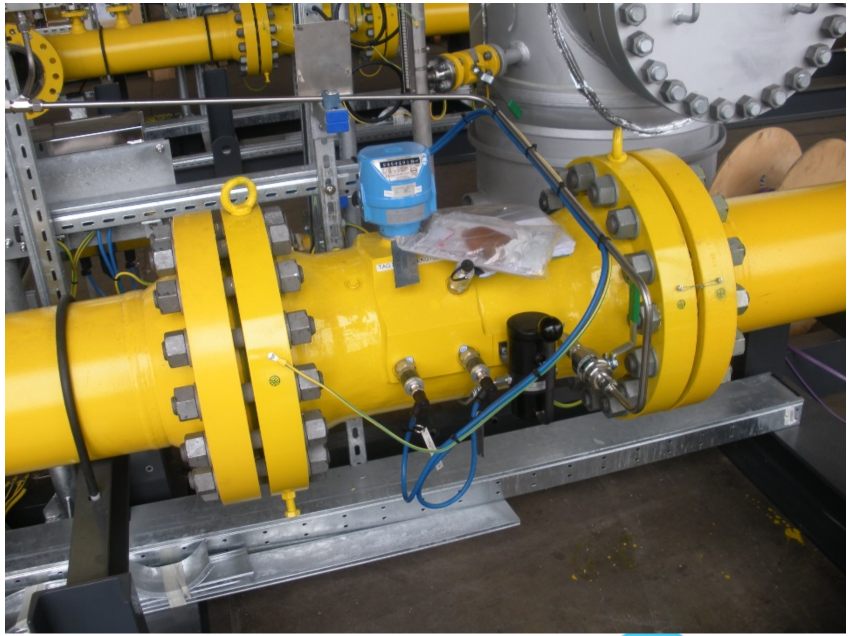
Compliance at Energy Facilities – Fuel Flow Analysis

- Heat Input (million Btu/hr, HHV) – hourly values
  - Regulators asking for data files, calculation methodology, accuracy determination
  - HHV values online vs. constant
  - Comparison to plant control system

Date/Hour	Unit 1 Fuel Flow (hscfh)	Unit 1 Heat Input (million Btu/hr)	Unit 1 Fuel Heating Value (Btu/scf)	Unit 1 Load (MW) Value	Unit 1 Heat Rate (Btu/kwhr, HHV)
07/01/2015 00	13480.1	1415.4	1050	109	12,985.3
07/01/2015 01	13235.1	1389.7	1050	106	13,110.4
07/01/2015 02	13238.3	1390	1050	106	13,113.2
07/01/2015 03	13253.4	1391.6	1050	106	13,128.3
07/01/2015 04	13257.1	1392	1050	106	13,132.1
07/01/2015 05	13243.4	1390.6	1050	106	13,118.9
07/01/2015 06	13262.6	1392.6	1050	106	13,137.7
07/01/2015 07	13241.3	1390.3	1050	105	13,241.0
07/01/2015 08	13232.1	1389.4	1050	106	13,107.5
07/01/2015 09	13224.7	1388.6	1050	106	13,100.0
07/01/2015 10	13223.9	1388.5	1050	106	13,099.1
07/01/2015 11	13235.2	1389.7	1050	105	13,235.2
07/01/2015 12	13239.5	1390.1	1050	106	13,114.2
07/01/2015 13	13236.5	1389.8	1050	106	13,111.3
07/01/2015 14	13238	1390	1050	106	13,113.2

Compliance at Energy Facilities – Fuel Flow Analysis

EPA Inspector Comparing Plant Distributed Control System Readings To CEMS Data Acquisition Readings



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Compliance at Energy Facilities
Startup and Shutdown Emissions

- Startup and Shutdown Emissions
  - One minute CEMS and DCS data
  - Is the site properly looking at startup and shutdown emissions?
  - No longer have blanket exemptions. Numerical standards for these events.
- CEMS often over-range during startups
  - Sites never bother to adjust range
  - Some use manual methods to adjust emissions (bad practice)
  - Inspectors looking at SU/SD events
- Annual Emissions Impacts
  - How do facilities account for startup, shutdown, malfunction?

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Daily Report

Hourly Emission Limits

NOx lb/hr - 68.8	Normal Operations	Startup/Shutdown
SO2 lb/hr - 11.2	CO lb/hr - 12.8	CO lb/hr - 128
PM lb/hr - 18	VOM lb/hr - 1.2	VOM lb/hr - 24

NOx exempt during startup

Hour	NOx lbs	CO lbs	SO2 lbs	PM lbs	VOM lbs	Gas Flow kscf	Turbine On-Time	Heat Input mmBtu	Process Status
00	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
01	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
02	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
03	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
04	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
05	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
06	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
07	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
08	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
09	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
10	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
11	DCal	Down	Down	Down	Down	Down	0.00	Down	Trip
12	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
13	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
14	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
15	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
16	85.4	48.73	0.2	8.0	9.1	757.0	0.60	798.7	Startup
17	51.6	0.00	0.5	9.3	0.2	1630.0	1.00	1720.0	Normal
18	52.3	0.00	0.5	9.4	0.2	1653.0	1.00	1744.2	Normal
19	50.7	0.00	0.5	9.4	0.2	1657.1	1.00	1748.6	Normal
20	53.7	69.68	0.3	11.4	13.0	1082.5	0.80	1142.2	Shutdown
21	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
22	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
23	Down	Down	Down	Down	Down	Down	0.00	Down	Trip
Average	58.7	23.68	0.4	9.50	4.5	1355.9		1430.7	
Total	293.7	118.4	2.0	47.5	22.7	6780	4.4	7154	

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Unit Shutdown Example – Monitor Range

	A	C	D	E	F	G	I
1	SHUTDOWN EXAMPLE						
2	Data for 4/22/2015 6:00 PM thru 4/23/2015 11:00 PM						
3	Timestamp	(Unit - 1) 60-NOx ppm 1-Min	(Unit - 1) NOx ppm @15% O2 1-Min	(Unit - 1) 60-NOx lb/mmBtu 1-Min	(Unit - 1) CO ppm 1-Min	(Unit - 1) CO ppm @15% O2 1 Min	(Unit - 1) 60-O2% 1-Min
163	4/22/2015 20:39	0.82	0.76	0.0028	19.4	17.9	14.53
164	4/22/2015 20:40	6.02	5.98	0.0219	80.9	80.3	14.96
165	4/22/2015 20:41	11.07	12.37	0.0452	317.8	355.1	15.62
166	4/22/2015 20:42	15.1	16.81	0.0614	397.6	442.6	15.6
167	4/22/2015 20:43	17.26	19.07	0.0697	780.0	861.8	15.56
168	4/22/2015 20:44	18.3	20.07	0.0734	1000.0	1096.7	15.52
169	4/22/2015 20:45	19.07	21.19	0.0775	1000.0	1111.1	15.59
170	4/22/2015 20:46	19.9	21.9	0.0801	1000.0	1100.7	15.54
171	4/22/2015 20:47	19.75	21.5	0.0786	1000.0	1088.6	15.48
172	4/22/2015 20:48	19.98	21.79	0.0796	1000.0	1090.6	15.49
173	4/22/2015 20:49	21.16	23.83	0.0871	1000.0	1126.0	15.66
174	4/22/2015 20:50	38.39	53.55	0.1957	1000.0	1394.8	16.67
175	4/22/2015 20:51	41.72	75.97	0.2777	1000.0	1821.0	17.66
176	4/22/2015 20:52	30.44	91.17	0.3332	1000.0	2994.9	18.93
177	4/22/2015 20:53	16.48	75.37	0.2755	1000.0	4573.6	19.61
178	4/22/2015 20:54	10.07	44.34	0.1621	491.6	2164.6	19.56
179	4/22/2015 20:55	7.56	32.32	0.1181	477.2	2040.2	19.52

Max range set 0-1000 ppm

Source was not aware that emissions were exceeding the monitor range during shutdowns (and startups)!

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Fuel Heat Input Issue – Biomass Gasification

Two Units – One Common Fuel Supply

- Permit requires hourly fuel heat input to wood chips supplied to gasifiers.
- Fuel quality varies
  - Heating value, moisture
  - How does fuel factor (Fd, Fc) for emission calculations apply for fuel that is gasified? Solid fuel to start, then gasified and the gasified fuel is burned in the boiler.
- Common supply belt feeds two units

Fuel Heat Input Issue – Biomass Gasification

Complicated by Two Units to Common Stack

Gasification Solution (not the best)

- Thermal performance testing for two gasifier units across the load range.
- Established relationship between steam flow and fuel feed.
  - Established heat input (million Btu/hr) as a function of steam flow.
- When two units are running, the main fuel feed is apportioned based on the amounts of steam being produced by each unit.

Estimated accuracy +/- 15% -- Impact on demonstration for ongoing emissions compliance.

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Possible Implications

- Facility is exploring options to improve compliance alternatives … all at a high cost!
  - Monitoring mass flow in exhaust ductwork for each unit to common stack.
  - Monitoring emissions in ductwork leading to the common stack.
- Compliance testing for single unit … must shut down other unit to isolate emissions from the operating unit being tested.

Initial cost savings from common stack and fuel handling can lead to compliance concerns in during operation.

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Predictive Emissions Monitoring

- Subpart Db Industrial Boilers can utilize operations monitoring plan to predict NOx emissions
  - Systems are acceptable as long as the plant instrumentation remains calibrated
  - QA checks to ensure boiler is operating within ranges established from testing

Retuning/testing necessary if adjustments are significant.

Moisture Based on O2 Monitoring – Impact of Instrument Uncertainty

- GIVEN:
  - Dilution based CO monitor (ppm, wet basis)
  - O2 probe (in situ, ppm wet)
  - O2 extractive (%, dry basis)
  - Limit of 160 ppmvd at 3% O2

- MOISTURE:
  - %H2O = 100-(%O2 (wet)*100/%O2 (dry))

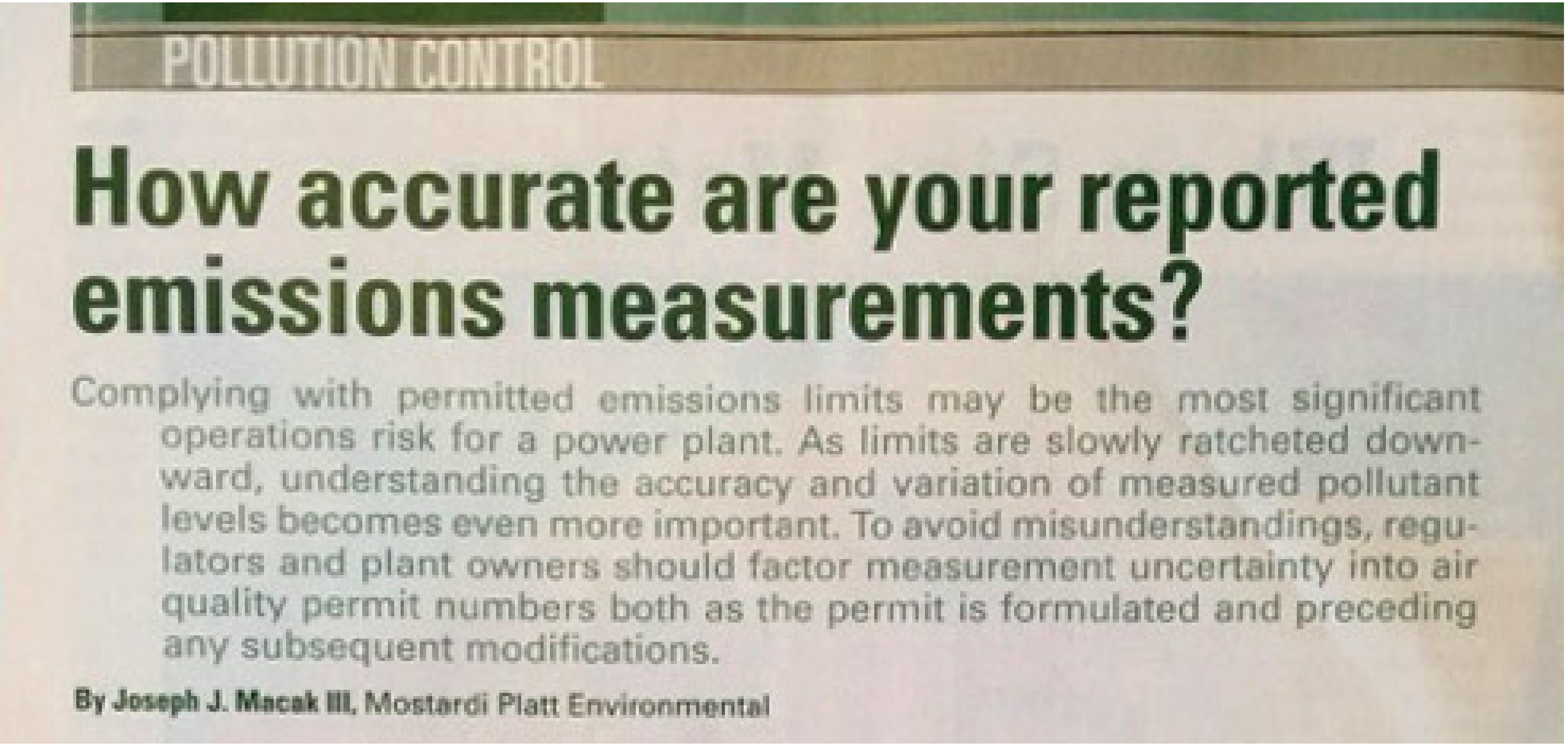
Moisture Based on O2 Monitoring – Impact of Instrument Uncertainty

- EXAMPLE 1:
  - CO = 115 ppm (wet)
  - In situ O2 = 4.5% (wet basis)
  - Dry O2 = 5.3% O2 (dry basis)
- MOISTURE:
  - %H2O = 100-(%O2 (wet)*100/%O2 (dry))
  - %H2O = 100-(4.5*100/5.3)
  - %H2O = 15.1%
- CO @ 3% O2:
  - CO dry = 115 * 100/(100-15.1)
  - CO dry = 135.4 ppmvd
  - CO (ppmvd at 3%) = 135.4 * (20.9-3)/(20.0-5.3%)
  - CO (ppmvd at 3%) = **155.4**

- Accuracy
  - In Situ Probe ≈ ± 0.25% O2
  - Dry O2 ≈ ± 0.25% O2
- Drift
  - If the In Situ O2 probe reads 4.3% (within accuracy) and the dry O2 is 5.5% O2 … moisture calculates as 21.8%
  - CO (ppmvd at 3% O2) = **171.0**

Cal gas accuracy also contributes to uncertainty

Permitting for Uncertainty



POLLUTION CONTROL

How accurate are your reported emissions measurements?

Complying with permitted emissions limits may be the most significant operations risk for a power plant. As limits are slowly ratcheted downward, understanding the accuracy and variation of measured pollutant levels becomes even more important. To avoid misunderstandings, regulators and plant owners should factor measurement uncertainty into air quality permit numbers both as the permit is formulated and preceding any subsequent modifications.

By Joseph J. Macak III, Mostardi Platt Environmental

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Permitting for Uncertainty

An example calculation for NO_x emissions for a combustion turbine follows. To calculate the NO_x emission rate in lb/million Btu (HHV) from the monitor data, the following equation derived from 40 CFR 60, Appendix A, Method 19, is used:

$$\text{(A)}\quad NO_X \text{ (lb / million Btu)} = \frac{\left(NOx\text{ (ppmvd)} * F_d * K_{NOx} * 20.9\right)}{\left(20.9 - \%O_2\text{, dry basis}\right)}$$

where:

NO_X (ppmvd) = NO_X concentration from continuous analyzer

F_d = Dry basis fuel factor equivalent to 8710 dscf/million Btu for natural gas (EPA default factor, or fuel specific equivalent)

K_{NOx} = Conversion factor for ppm (NO_x) to lb/scf, which is equivalent to the value 1.194E-07 for NO_x

O_2 = Percent by volume of oxygen as measured on a dry basis with continuous analyzer.

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Permitting for Uncertainty

To calculate fuel heat input to the combustion turbine, fuel flow (kscfh) is monitored and a direct calculation of heat input is performed.

$$\text{(B) Heat Input (million Btu/hr)} = \text{fuel flow}\left(\frac{\text{kscf}}{\text{hr}}\right) * 1015\left(\frac{\text{Btu}}{\text{scf}}\right) * 1000\left(\frac{\text{scf}}{\text{ksch}}\right) * 10^{-6}\left(\frac{\text{million Btu}}{\text{Btu}}\right)$$

To calculate lb/hr, the lb/million Btu values are multiplied by the fuel heat input to the boiler (million Btu/hr) as follows:

$$\text{(C) } NO_x \text{ (lb/hr)} = NO_x\text{(lb/million Btu)} * \text{Heat Input (million Btu/hr)}$$

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Permitting for Uncertainty

The dry basis fuel factor (F_d) in equation (A) can be adjusted from the default version using 40 CFR 60, Appendix A, Method 19, using the following equation:

$$(D)\ F_d = 10^6 * [3.64(\%H)+1.53(\%C)+0.57(\%S)+0.14(\%N)-0.46(\%O)]/GCV$$

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Permitting for Uncertainty – Sources of Error for Mass Emission Calculations

- Instrumentation accuracy – NOx Analyzer, Oxygen Analyzer
- Calibration Gas accuracy
- Fuel Flow Meter (+/- 2.5%)
- Fuel Heating Value (Btu/scf or Btu/lb)
- Stratification in the stack (single point monitored by probe)
- Equipment degradation over time
  - Emissions may get worse from the original warranty information used in permitting.
- CEMS Equipment/System performance (e.g. conditioner not working as well as expected)
- Units of the emission standard (how many decimal places???)

Permitting for Uncertainty – Uncertainty Simulation

Table 1. Analysis Conditions for CEMS Emission Calculation.

	Actual Value	+/- Value	Minimum	Maximum	Std. Dev.
NO_x	9	1.25	7.75	10.25	0.417
O_2	14.5	0.75	13.75	15.25	0.250
Fuel Factor, F_d	8685	25	8660	8710	8.333
Fuel Flow, kscfh	1800	30	1770	1830	10.000
Fuel Heating Value, Btu/scf	1015	20	995	1035	6.667
Calculated by CEMS					
Heat Input (million Btu/hr)	1827		1761.2	1894.1	
NO_x (lb/million Btu)	0.03048		0.02342	0.03943	
NO_x (lb/hr)	55.68		41.25	74.69	

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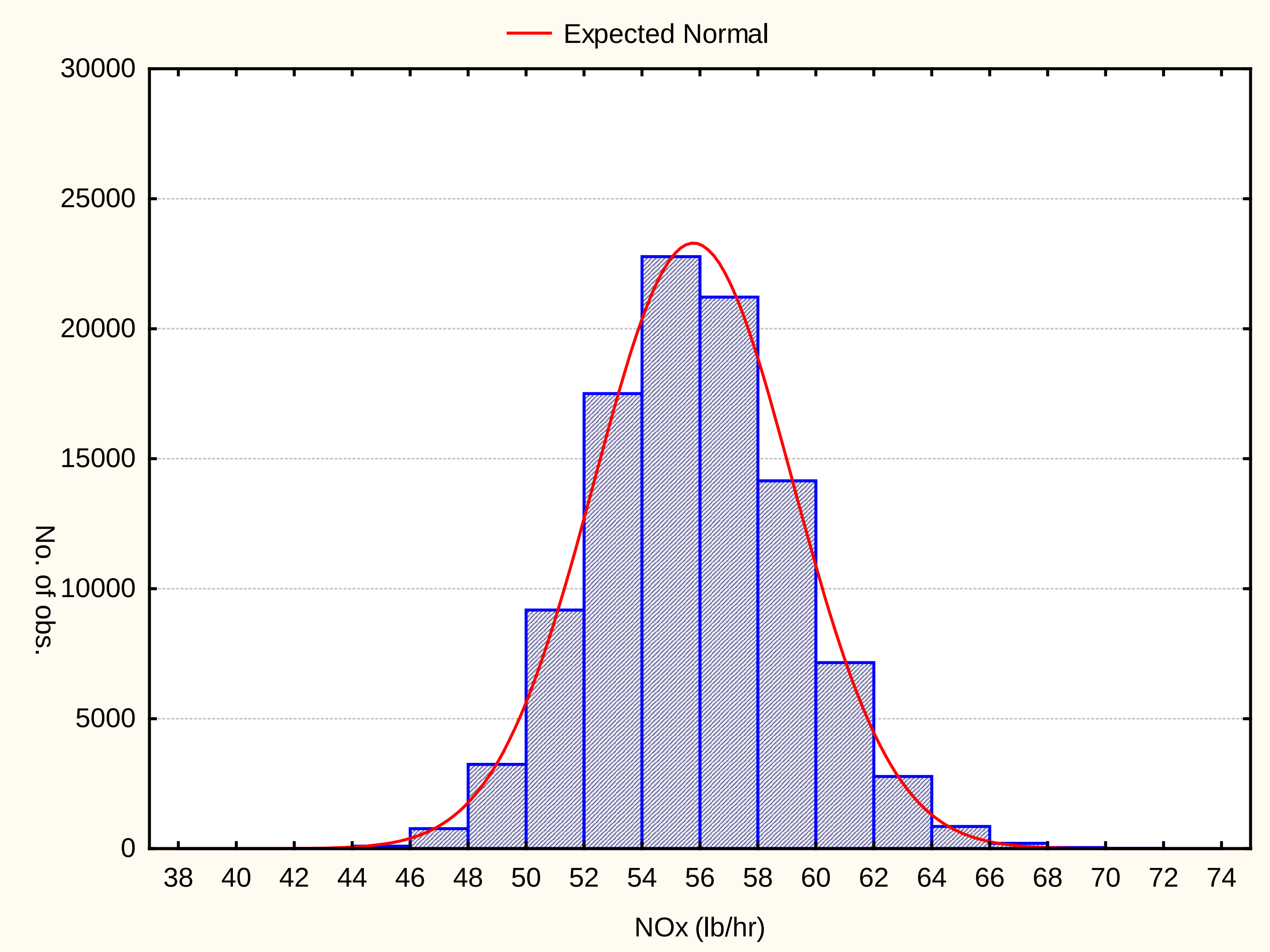
Permitting for Uncertainty – Uncertainty Simulation

Table 2. Descriptive Statistics of Input and Calculated Parameters.

Parameter	# of cases	Mean	Median	Min	Max
NO_x (ppmvd)	100000	**9.00**	9.00	7.09	10.89
O_2 (%, dry)	100000	**14.50**	14.50	13.47	15.55
F_d	100000	**8685.0**	8685.0	8649.4	8720.1
Fuel Flow (kscfh)	100000	**1800.0**	1800.0	1757.6	1841.8
Fuel Heating Value (Btu/scf)	100000	**1015.0**	1015.1	985.4	1045.4
NO_x (lb/million Btu)	100000	**0.0305**	0.0305	0.0232	0.0401
Heat Input (million Btu/hr)	100000	**1827.1**	1827.0	1758.0	1894.9
NO_x (lb/hr)	100000	**55.77**	55.69	42.14	73.96

		Percentile Values					
Parameter	**# of cases**	**65%**	**75%**	**80%**	**95%**	**99%**	**99.70%**
NO_x (ppmvd)	100000	9.16	9.28	9.35	9.69	9.97	10.15
O_2 (%, dry)	100000	14.60	14.67	14.71	14.91	15.08	15.18
F_d	100000	8688.2	8690.6	8692.0	8698.8	8704.5	8708.0
Fuel Flow (kscfh)	100000	1803.8	1806.8	1808.5	1816.5	1823.5	1827.7
Fuel Heating Value (Btu/scf)	100000	1017.6	1019.6	1020.7	1026.0	1030.4	1033.2
NO_x (lb/million Btu)	100000	0.0312	0.0317	0.0321	0.0337	0.0351	0.0360
Heat Input (million Btu/hr)	100000	1833.1	1837.7	1840.3	1853.0	1863.6	1871.0
NO_x (lb/hr)	100000	57.01	58.02	58.61	61.57	64.17	65.75

Permitting for Uncertainty – Uncertainty Simulation



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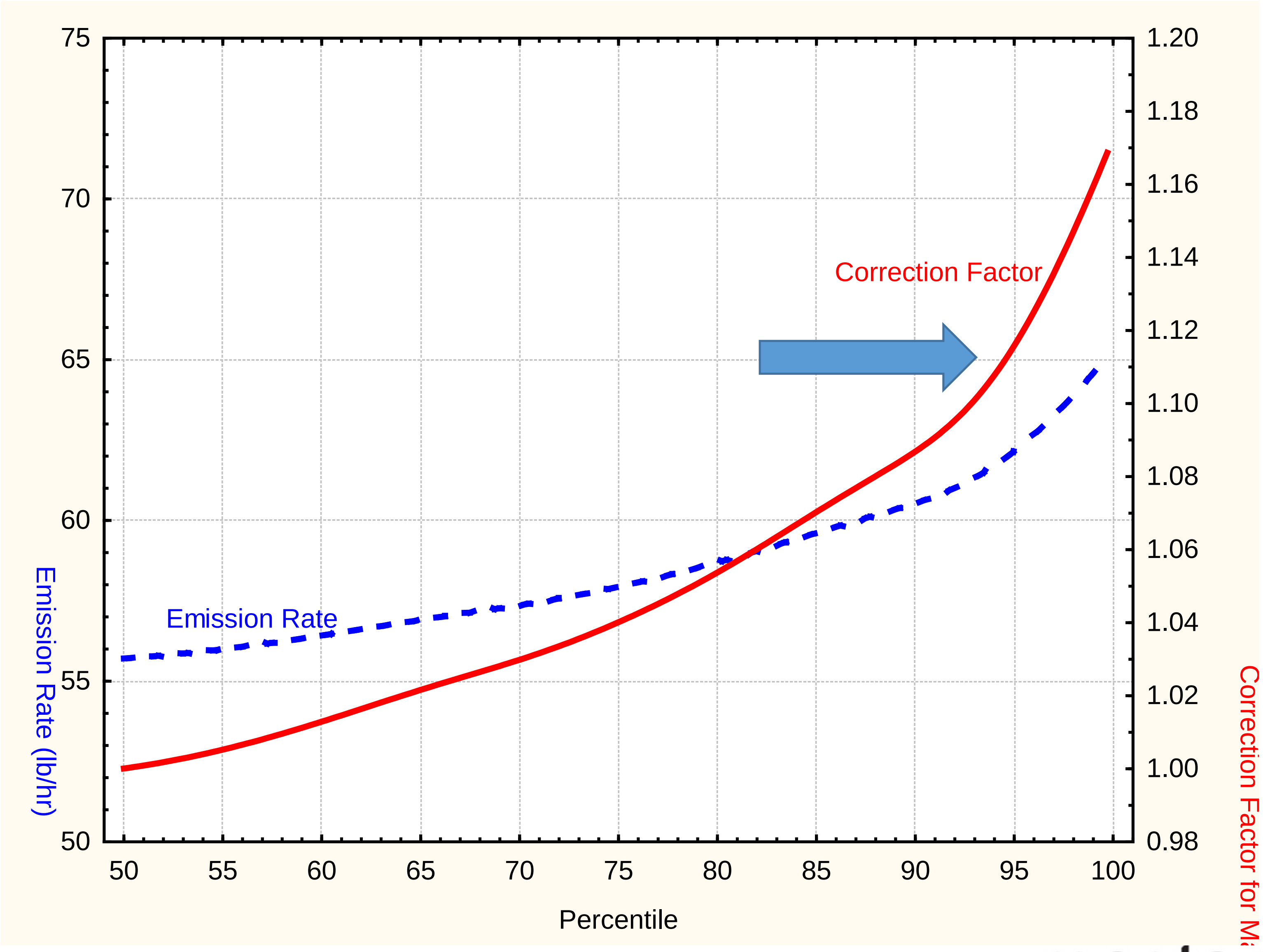
Permitting for Uncertainty – Uncertainty Simulation



Summary

- Make sure your permit conditions make sense, and get them changed if you don't agree with the regulators.
  - Speak up or suffer the consequences.
- Data quality must be perfect. If something doesn't make sense, dig further.
- Build in measurement uncertainty into your construction and operating permits.
  - Reliance on manufacturer's guarantees is a mistake since they are based on new and clean equipment, and for specific operating conditions.

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For further information …

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