18th SYMPOSIUM ON INDUSTRIAL APPLICATIONS OF GAS TURBINES

NOx Emission Factors for UnControlled Gas Turbines in Natural Gas Pipeline Compressor Drive Service

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Purpose

The purpose of this paper is to communicate to industry a data set of NOx stack test results, compare them to the AP42 emission factor prediction, and describe a practical apparent correlation that could be applied in NOx inventory application, with improved accuracy compared to conventional methods.

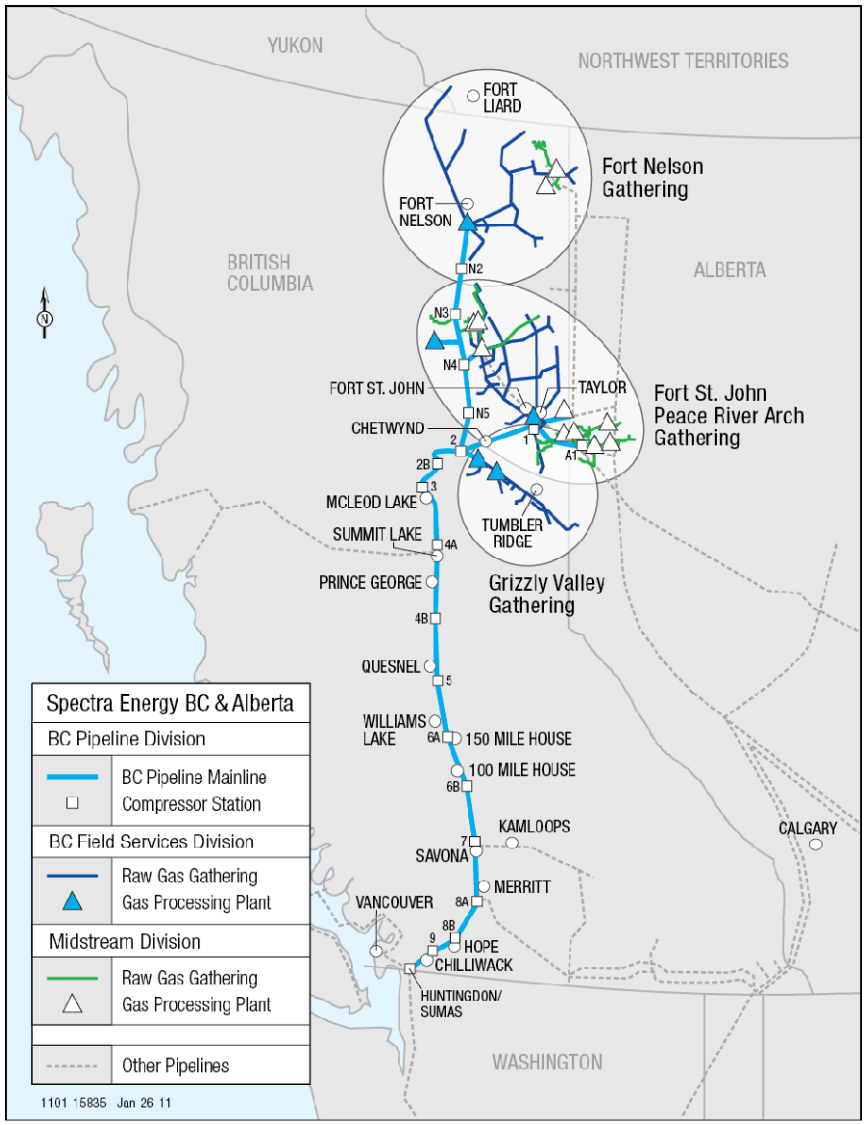
and to;

Present to a peer audience for feedback.

Agenda

- SET Canada West System Overview
- AP 42
- SET Canada West Stack Test Results
- Stack Tests versus AP 42
- DLE versus AP 42
- Summary, Q&A

SET Canada West System Overview



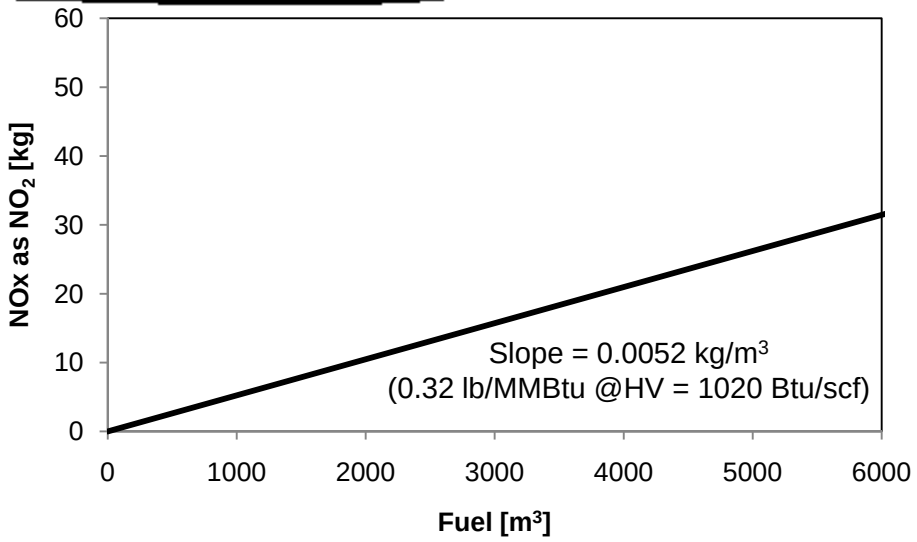
Turbo-Compressor Equipment

	Gas Generator	Power Turbine	ISO Power [kW]	Driven Compressor
Coberra 3045	Spey mk1900	RT45	11930	PV30x30
Ingersoll-Rand GT-51	LM1500GB102	GT51	10570	CDP-30
Nuovo Pignone PGT25	LM2500GE	PGT25	23270	PCL-804
Dresser-Rand DR60G	LM1600G	ELM1600	14250	CDP-230
Solar Taurus 60	Taurus 60-T7000		5220	CDP-416

AP 42

Table 3.1-1. EMISSION FACTORS FOR NITROGEN OXIDES (NO_X) AND CARBON MONOXIDE (CO) FROM STATIONARY GAS TURBINES

Emission Factors[a]				
Turbine Type	Nitrogen Oxides		Carbon Monoxide	
Natural Gas-Fired Turbines[b]	(lb/MMBtu)[c] (Fuel Input)	Emission Factor Rating	(lb/MMBtu)[c] (Fuel Input)	Emission Factor Rating
Uncontrolled	3.2 E-01	A	8.2 E-02[d]	A
Water-Steam Injection	1.3 E-01	A	3.0 E-02	A
Lean-Premix	9.9 E-02	D	1.5 E-02	D
Distillate Oil-Fired Turbines[e]	(lb/MMBtu)[f]	Emission Factor	(lb/MMBtu)[f]	Emission Factor Rating

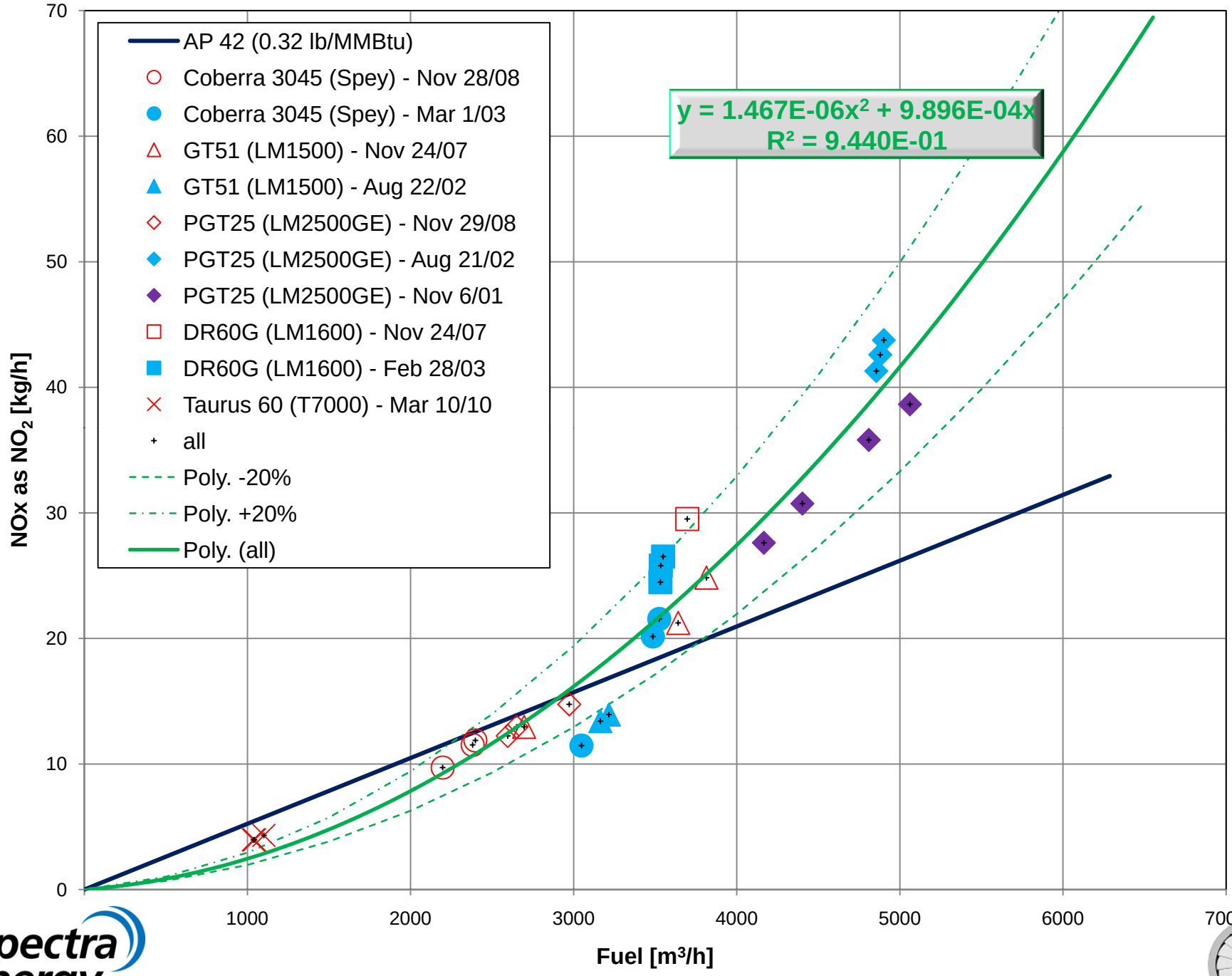


Stack Test Results

- 10 of 24 Stack tests analyzed
- Several tests removed from data set:
  - DLE Type Units
  - Load related data erroneous or not logged
  - Fuel data erroneous
  - Units not EGT instrumented

(e.g.: several W92 stack tests correlate similarly, but TIT fuel governor limited, these do not have EGT)

- Curve Fit
- Measurement Uncertainty


AP 42 (0.32 lb/MMBtu)
Coberra 3045 (Spey) - Nov 28/08
Coberra 3045 (Spey) - Mar 1/03
GT51 (LM1500) - Nov 24/07
GT51 (LM1500) - Aug 22/02
PGT25 (LM2500GE) - Nov 29/08
PGT25 (LM2500GE) - Aug 21/02
PGT25 (LM2500GE) - Nov 6/01
DR60G (LM1600) - Nov 24/07
DR60G (LM1600) - Feb 28/03
Taurus 60 (T7000) - Mar 10/10
all
Poly. -20%
Poly. +20%
Poly. (all)
y = 1.467E-06x² + 9.896E-04x
R² = 9.440E-01
NOx as NO2 [kg/h]
Fuel [m³/h]
0
10
20
30
40
50
60
70
1000
2000
3000
4000
5000
6000
7000

Stack Test Observations

- **Data Point Symbols = Discrete Test**
  - **Symbol Shape = Same Turbine Model**
  - **Label "all" (small +) for Excel Curve Fit**
  - **Dashed Line, ±20% of Curve Fit**
- **Ambient Temperature range typically near 0°C (some models ~ 0°C to ~20°C)**
- **Site Elevations 540m to 850m (ambient pressure ~94.95 kPa to 91.45 kPa)**
- **Measurement Uncertainty (see Hung & Campbell)**
- **Excel Curve fit with Correlation Coefficient of 0.97 ($\sqrt{0.9440}$)**

DLE versus AP 42

1992 CCME Guidelines for Stationary Combustion Turbines Appendix B factor for Natural Gas Fuel

1 ISO ppmv NOx = 1.70 grams NO_2 per GJ of heat input gives; ppmv x 1.70 x 0.0022 lb/gram x 1.054615 GJ/MMBtu

- **25 ppmv → 0.099 lb/MMBtu**
- **40 ppmv → 0.158 lb/MMBtu**

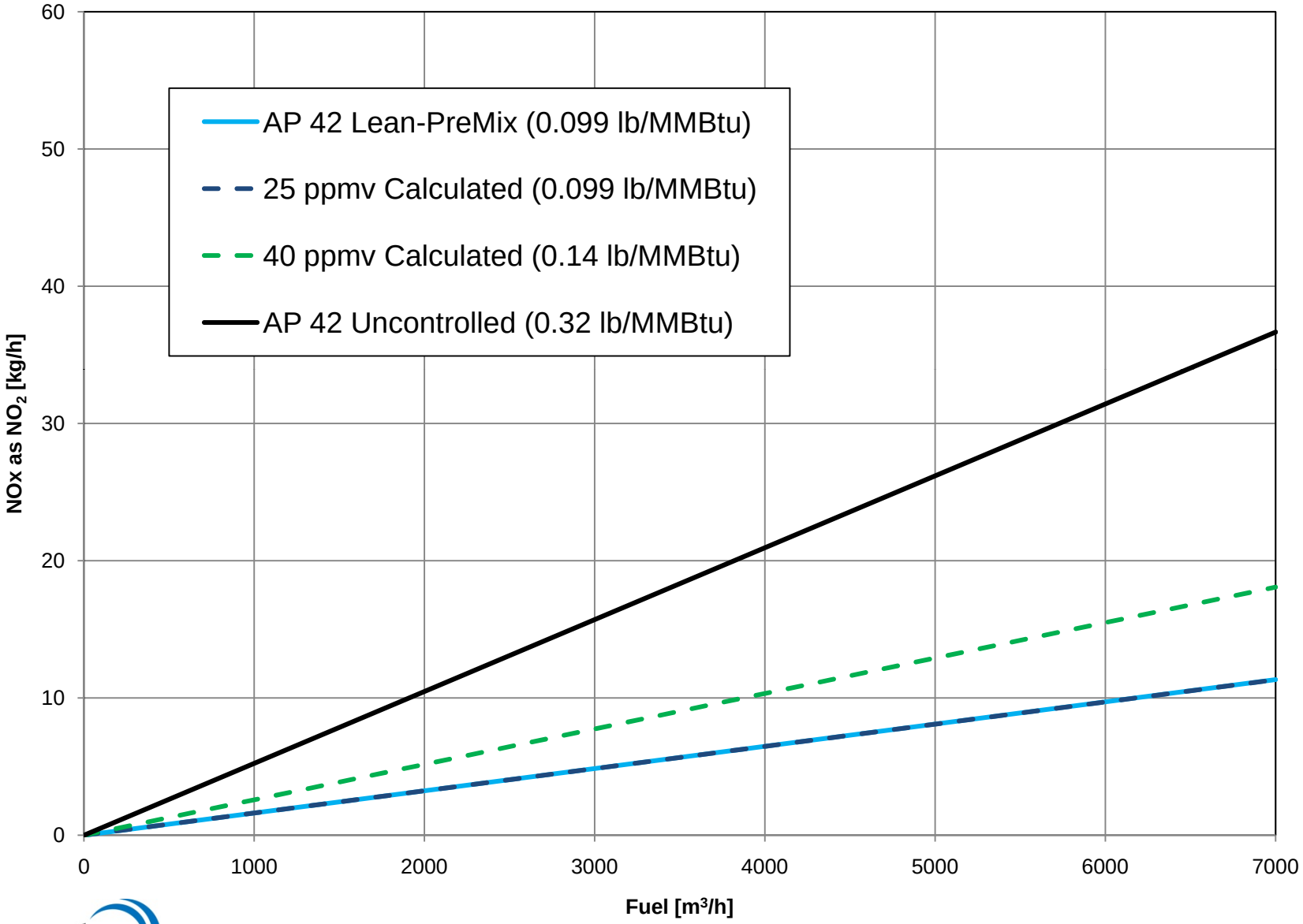
AP 42 for Lean Pre-Mixed Stationary Combustion Turbines;

- **0.099 lb/MMBtu (i.e.: 25 ppmv machine)**

Spectra Energy

IAGT™

Lines of Constant NOx Concentration at 15% O_2



Conclusions

- **NOx emissions of UnControlled gas turbines in natural gas pipeline compression service can be quantified as a function of measured natural gas fuel with a second order polynomial representative of many models of gas turbines**

- **NOx emissions for DLE gas turbines with NOx at 15% O2 constant over their operated power range, can be quantified with conventional emission factors as a function of fuel**

Q&A