



Tecogen Retrofit Demonstration, Sustained Compliance & Digester Gas Project

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3/22/16

Background on EMWD



- 542 square mile service area
- Approximately 785,000 people served
- Operate 58 prime engines with 3 using digester gas
- One full time emission test coordinator/tester
- One contractor specifically for SCAMQD Rule 1110.2 to track and report parameters out of range, make notifications and prepare reports, such as deviations, breakdowns, and quarterly/annual.
- Significantly impacted by SCAQMD Rule 1110.2



Topics:



- Attraction to Tecogen
- How Tecogen System functions (Pettit Installation)
- Natural gas demonstration project goals and results
- Update on digester gas demonstration project
- Potential benefits of Tecogen System for EMWD



- Woodward E3 Trim system test results (3.5 years)



Tecogen - What's the Attraction?



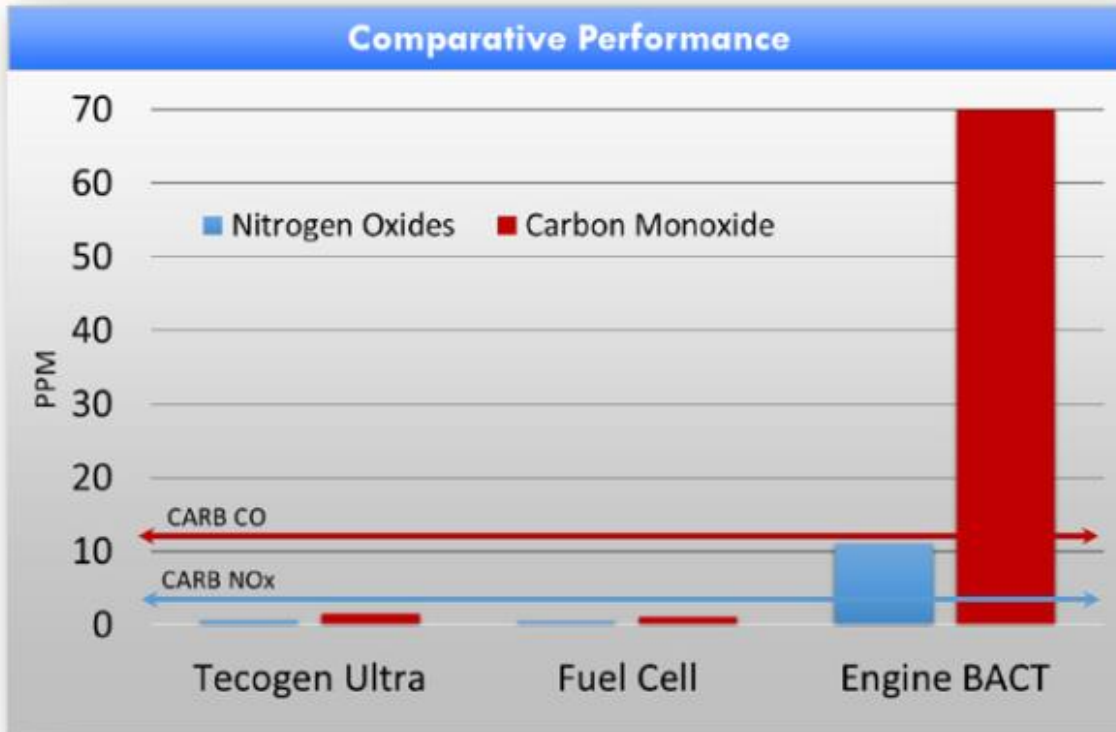
- Good data from prior installation
- Simple and familiar components
- Relatively low cost and ease of installation
- Wider AFRC window
- Essential Services need reliable technology
- Save Endangered Engines!



POTW Energy Independence??



Tecogen Confident in Technology



1) Tecogen emissions based upon actual third party source test data

2) Fuel Cell emissions from Summary Report - Fuel Cell Emission, CEC Grant PNG-06-002, by University of California Irvine-Subcontract UCI-06-002.

3) Stationary engine BACT as defined by SCAQMD.

4) Limits represent CARB 2007 emission standard for Distributed Generation with a 60% (HHV) Overall Efficiency credit



Demonstration Project - Natural Gas Engine



- Gas Co. provided funding support to Tecogen to design 6 models & install one unit
- Conducting Demo Project at Pumping Station
(Cat Model G342, 225 HP, Rich Burn Nat Gas Engine, Pump, Naturally Aspirated, Altronic EPC-100 AFRC)
- Overall Goal → **Sustained, Hassle-free Compliance Over Wide Operating Range**



Criteria for Success



- Limited installation problems. Easy access to catalyst & HX.
- Pass required portable analyzer tests. Stay on monthly test schedule for 3 to 4 months at a time.
- Compliance over a broad range of operating parameters: 900-1200 RPM, 2000-4000 GPM, 0-10 in. Manifold Vac
- Costs not to exceed 110% of preliminary estimate
- No unusual or frequent maintenance issues



Exhaust Modifications

CATALYST

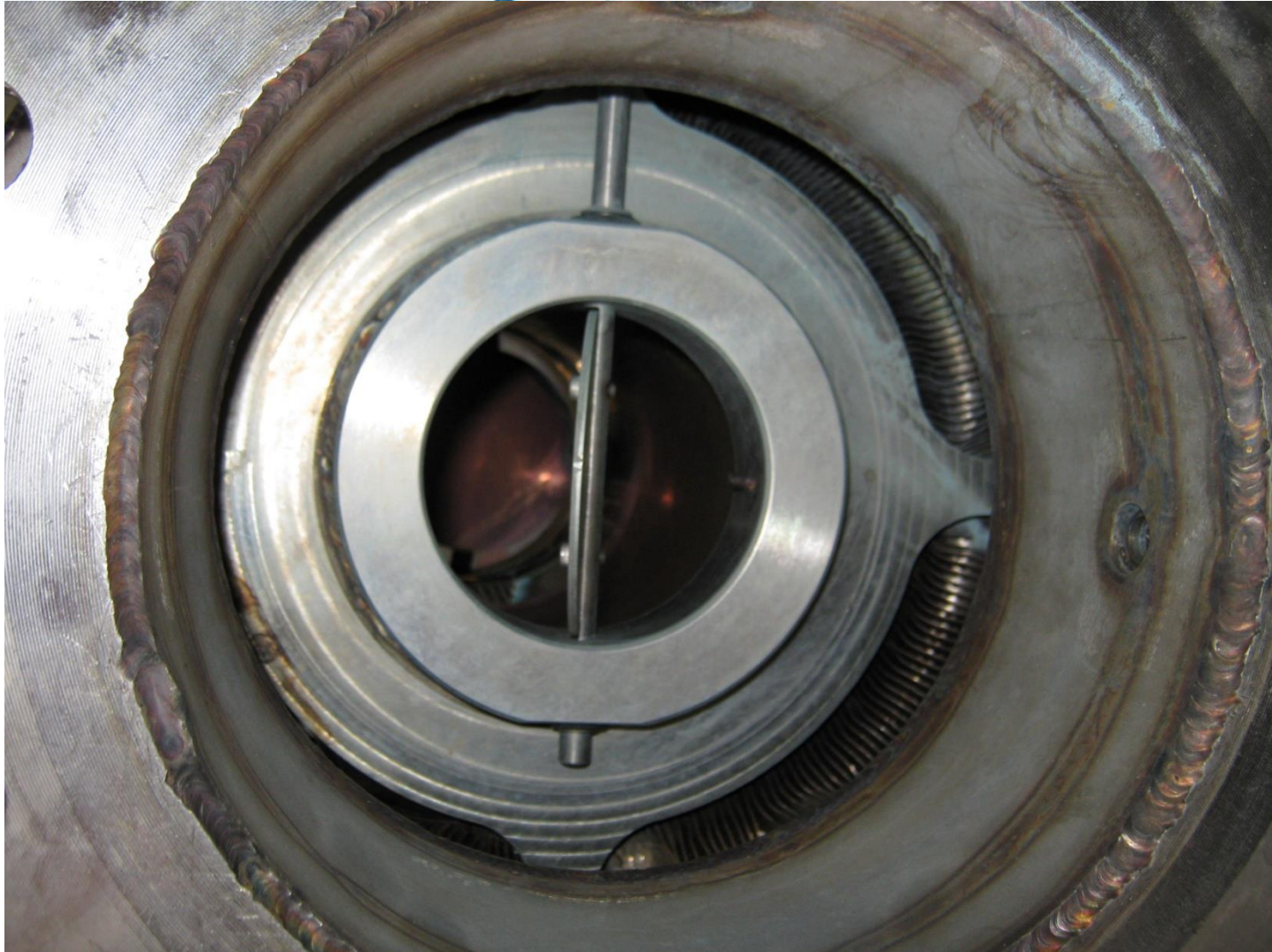
CATALYST

HEAT
EXCHANGER

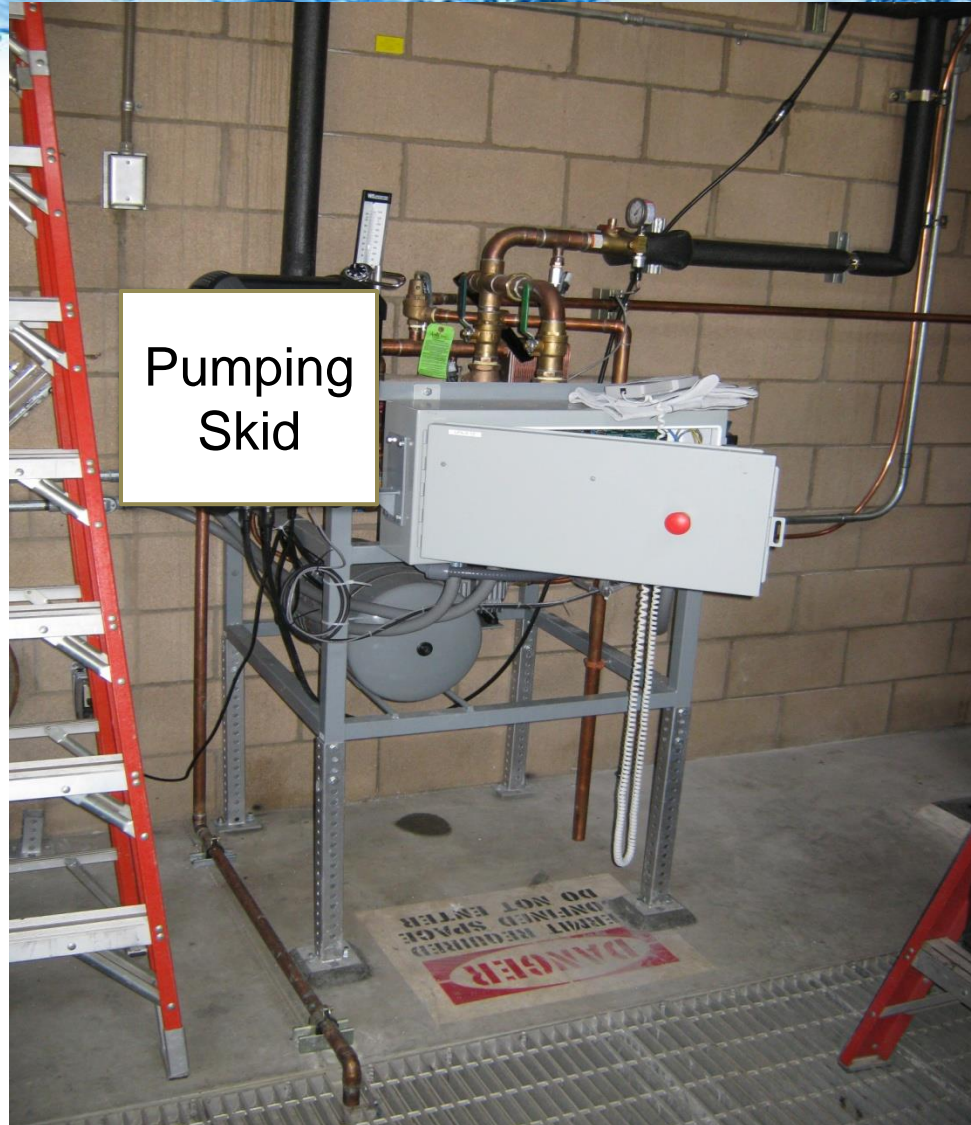


INSTALLATION AT HEACOCK PETTIT BOOSTER PUMP STATION

Butterfly Valve Inside Heat Exchanger

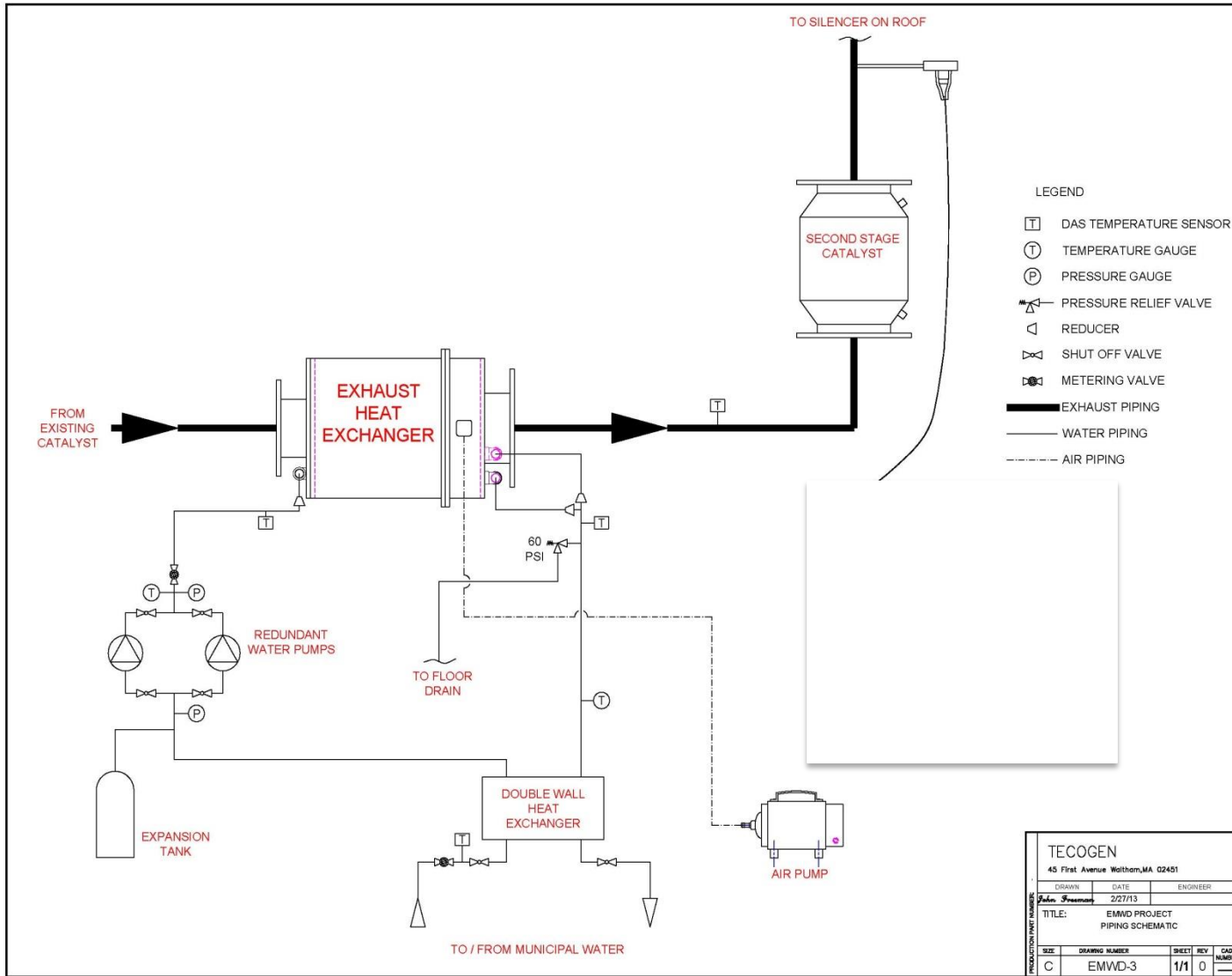


Pumping Skid



Pumping
Skid

Drawing

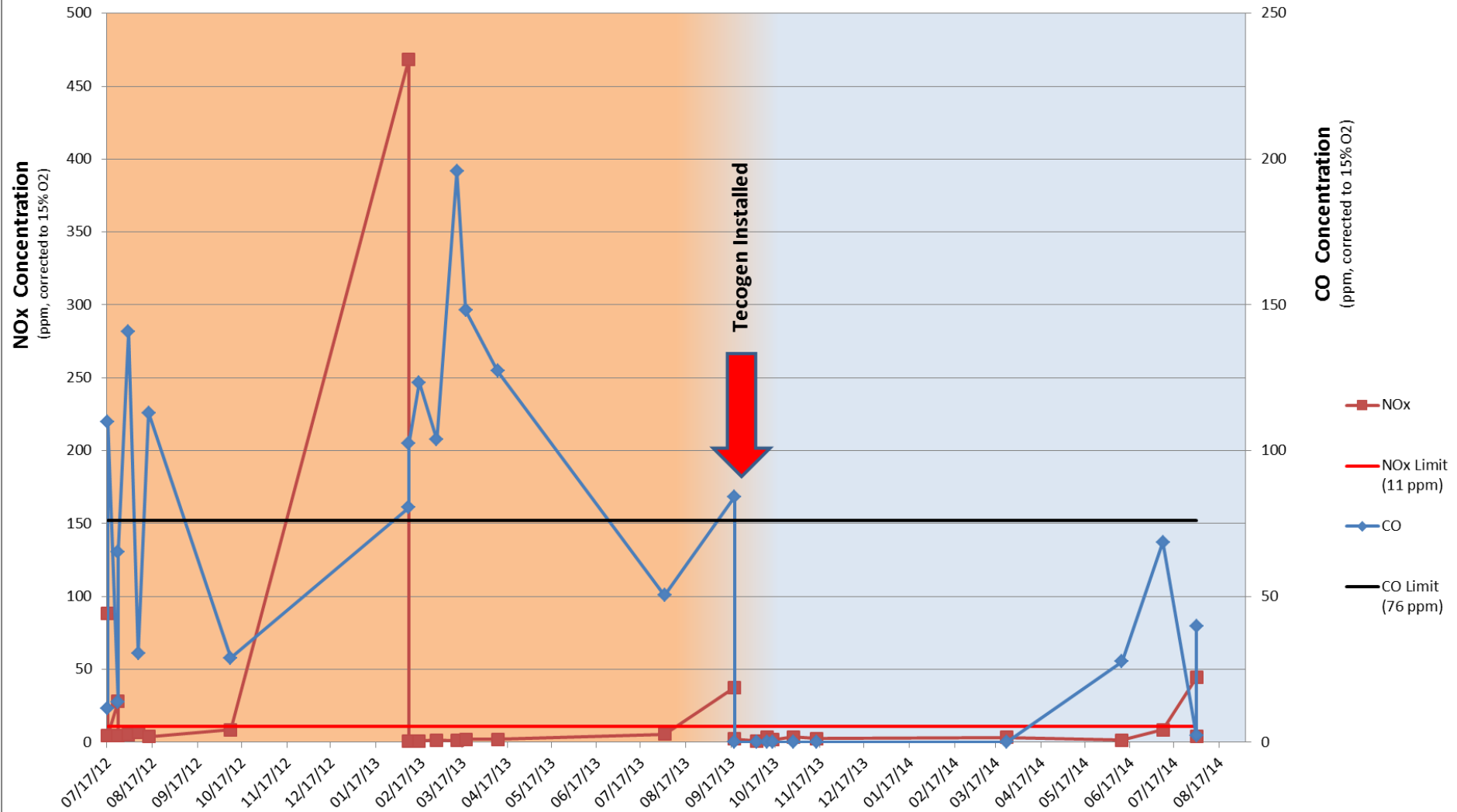


TECOGEN				
45 First Avenue Waltham, MA 02451				
DRAWN	DATE	ENGINEER		
John Swanson	2/27/13			
TITLE: EMWD PROJECT PIPING SCHEMATIC				
SIZE	DRAWING NUMBER	SHEET	REV	CAD NUMBER
C	EMWD-3	1/1	0	

First Year of PA Test Data



Tecogen Criteria Emission Test Results

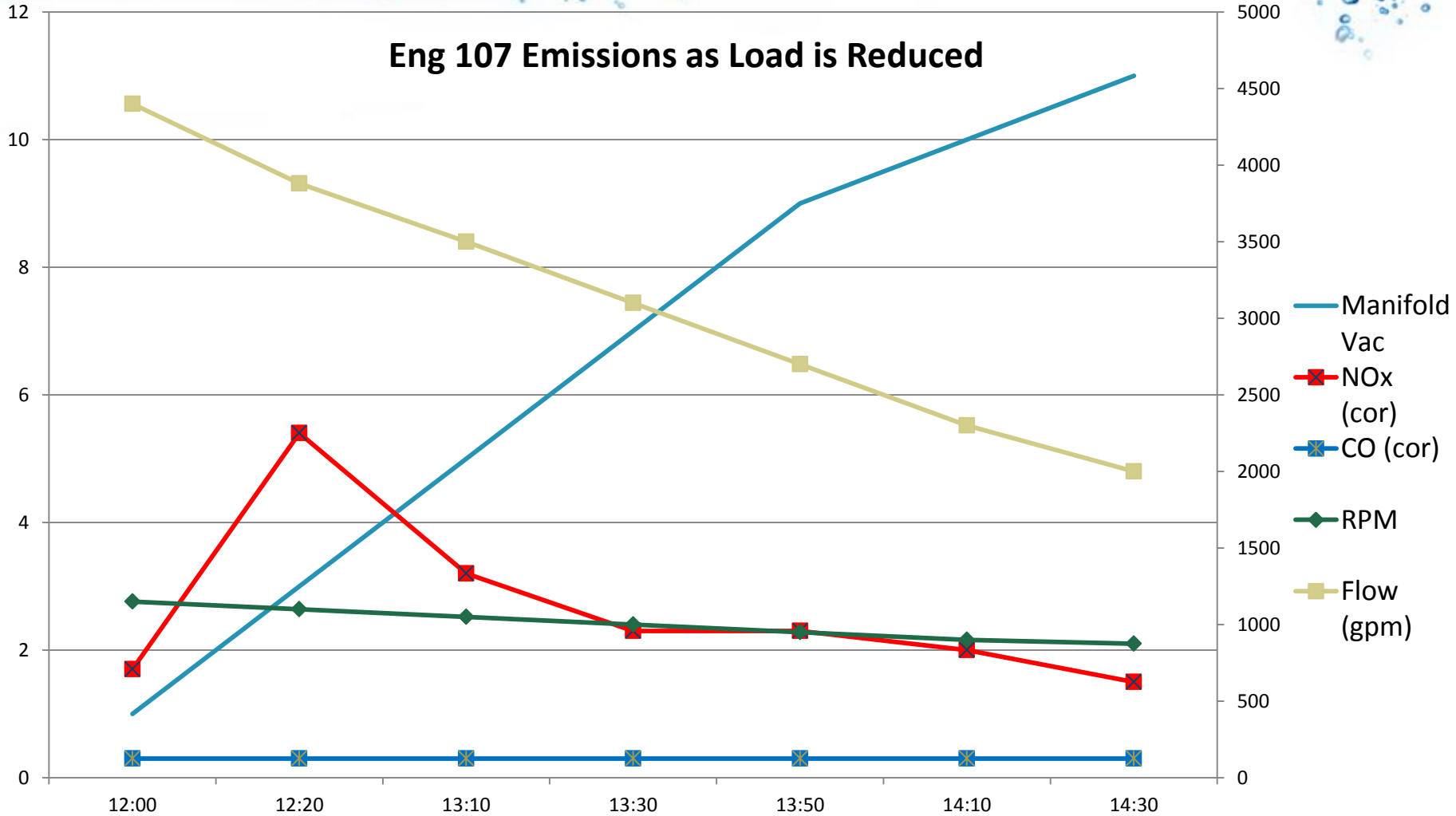


Official Portable Analyzer Test Results



Test No.	Date	CO @ 15% O2 (ppm)	NOx @ 15% O2 (ppm)	Notes	Op Hrs Between Tests	Avg. Op Hrs Btwn Tests
46	07/17/12	11.5	88.6	Fail	558.6	
47	07/17/12	109.9	4.9		0.7	
48	07/24/12	13.9	28.0	Fail	85.7	
49	07/24/12	65.4	4.5		0.6	
50	07/31/12	140.9	5.1		81.3	
51	08/07/12	30.6	6.7		56.1	
52	08/14/12	113.0	3.9		73.8	
53	10/09/12	29.0	8.5		517.1	
54	02/08/13	80.5	468.4	Fail	619.6	
55	02/08/13	102.4	1.0		1.1	
56	02/15/13	123.4	0.9		91.8	
57	02/27/13	103.8	1.4		100.8	
58	03/13/13	195.8	1.3		58.1	
59	03/19/13	148.2	2.0		39.2	
60	04/10/13	127.4	2.1		176.4	
61	08/02/13	50.4	5.7		614.7	
62	09/19/13	84.2	37.5	Fail	391.2	204
63	09/19/13	0.0	2.3	Tecogen Install		
64	10/04/13	0.0	1.0			
65	10/11/13	0.0	3.5			
66	10/15/13	0.0	1.8			
67	10/29/13	0.0	3.6			
68	11/14/13	0.0	2.6			
69	03/24/14	0.0	3.4			
70	06/11/14	27.7	1.6			
71	07/09/14	68.6	8.5			
72	08/01/14	2.2	44.5	Fail		
73	08/01/14	39.8	3.9	Adjust AFRC		

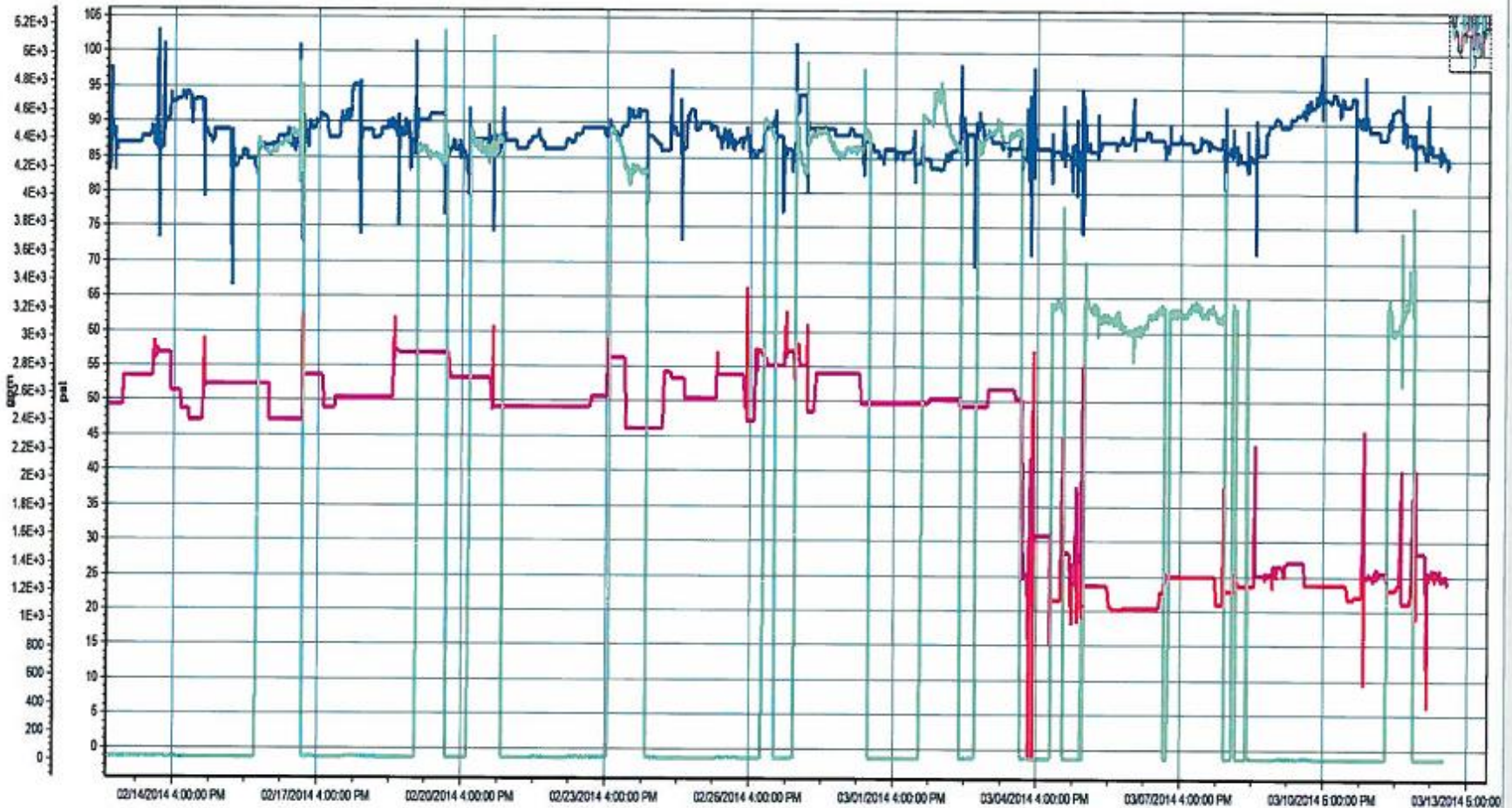
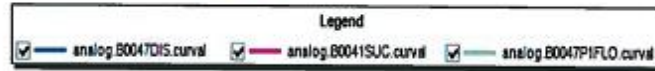
Compliance Over Full Operating Range



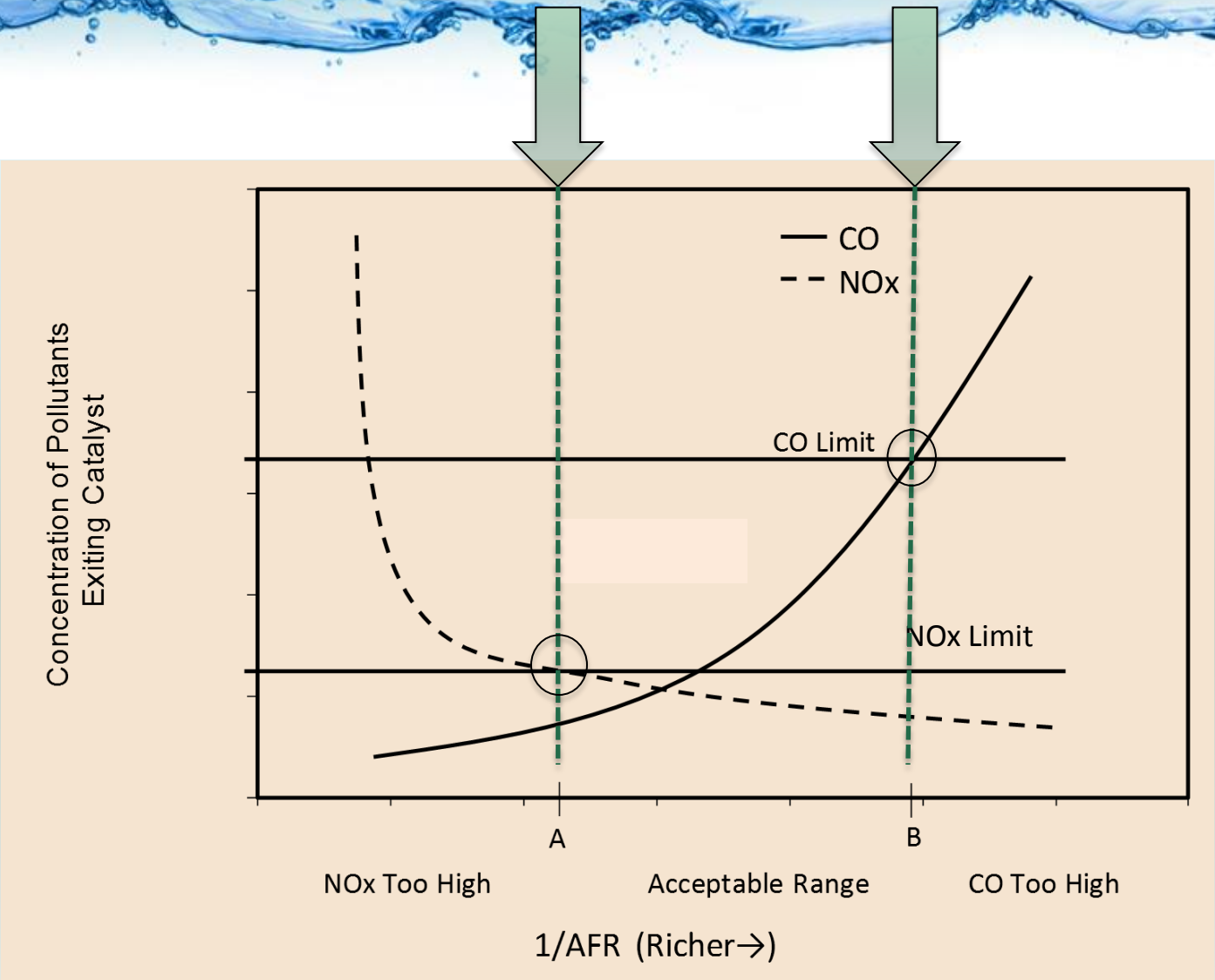
Compliance at Low Suction Pressure



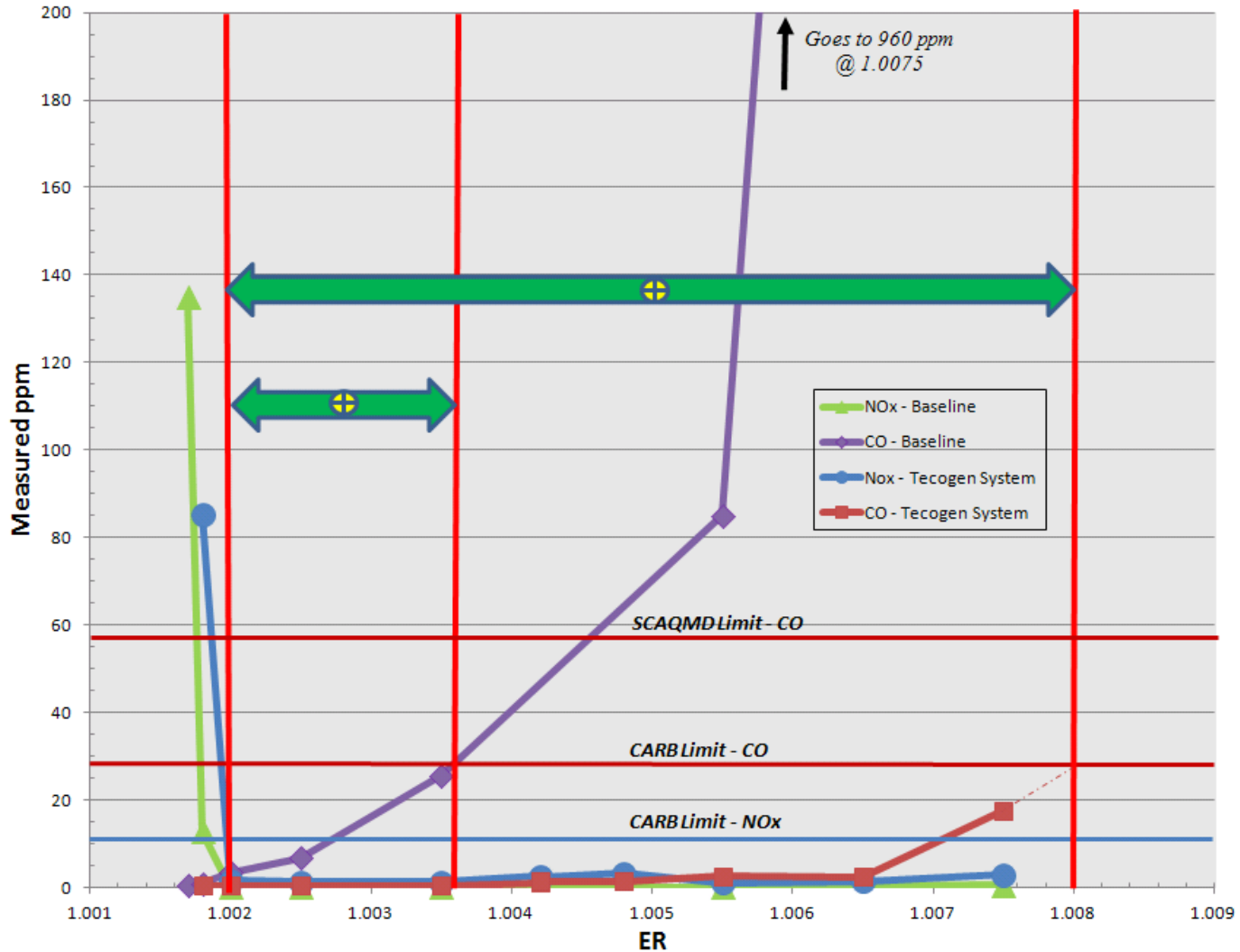
DNA Chart



Typical AFRC Window



AFRC Window Widened Three Times!



Key Benefits of Retrofit



- **Sustained low emissions**
(2783 hrs before first test fail, Compliance over entire operating range)
- **Comparatively Low Cost** (~\$40k per engine ~300 hp engine)
- **3X Wider AFRC window** (primary cause of failed portable tests)
- **Familiar Components, Simple, and Low Maintenance**
- **Less labor keeping engines in compliance**
(750 hr vs 150 hr test schedule)



MVRWRF Digester Gas Tecogen Project



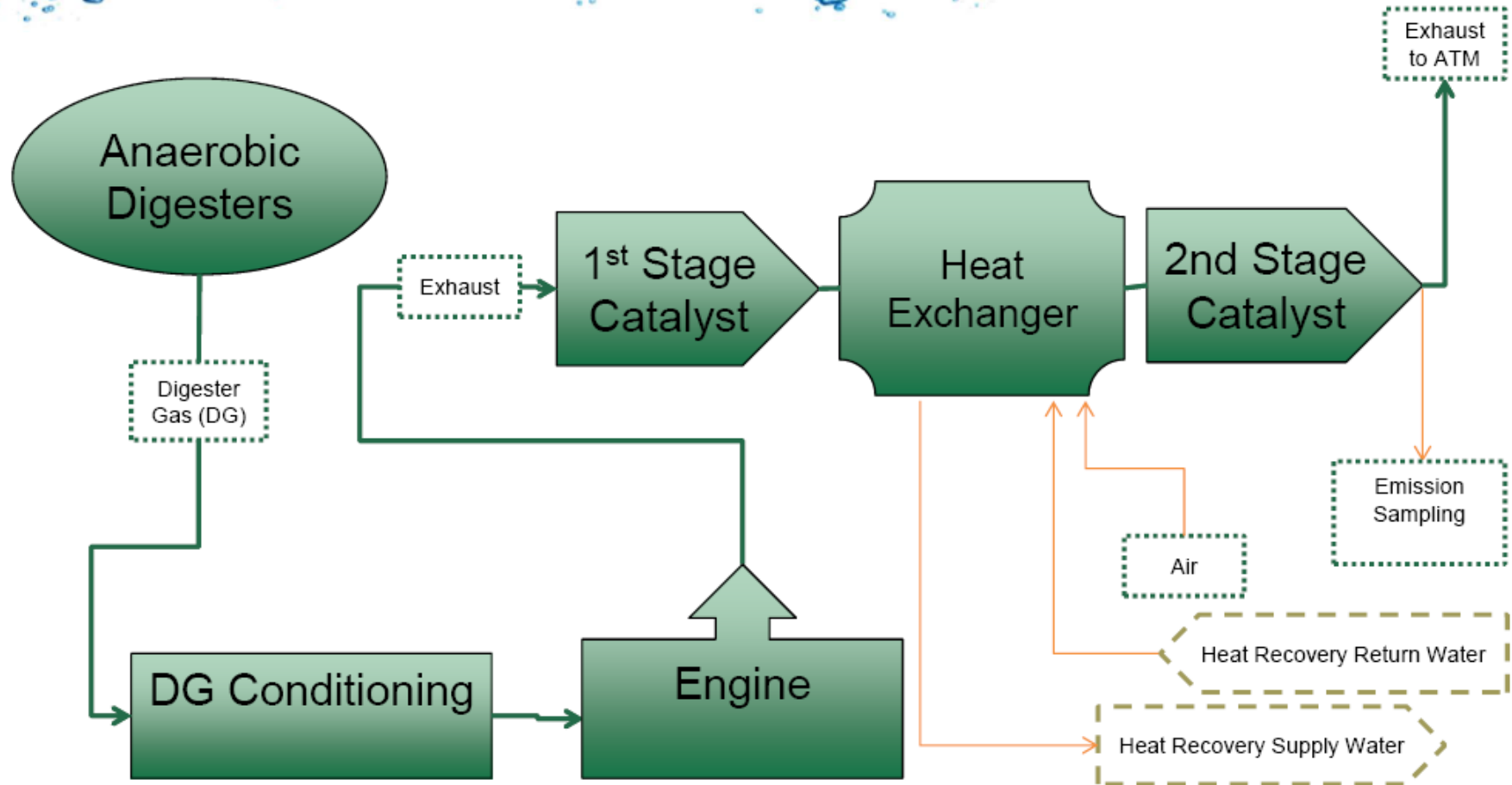
- Solution needed to comply with Rule 1110.2 emission limits for Digester Gas engines
(11 ppm NO_x, 250 ppm CO corrected)
- Nearly given up on digester gas engines at MVRWRF
- Engines had been permitted for natural gas only

MVRWRF Digester Gas Tecogen Project



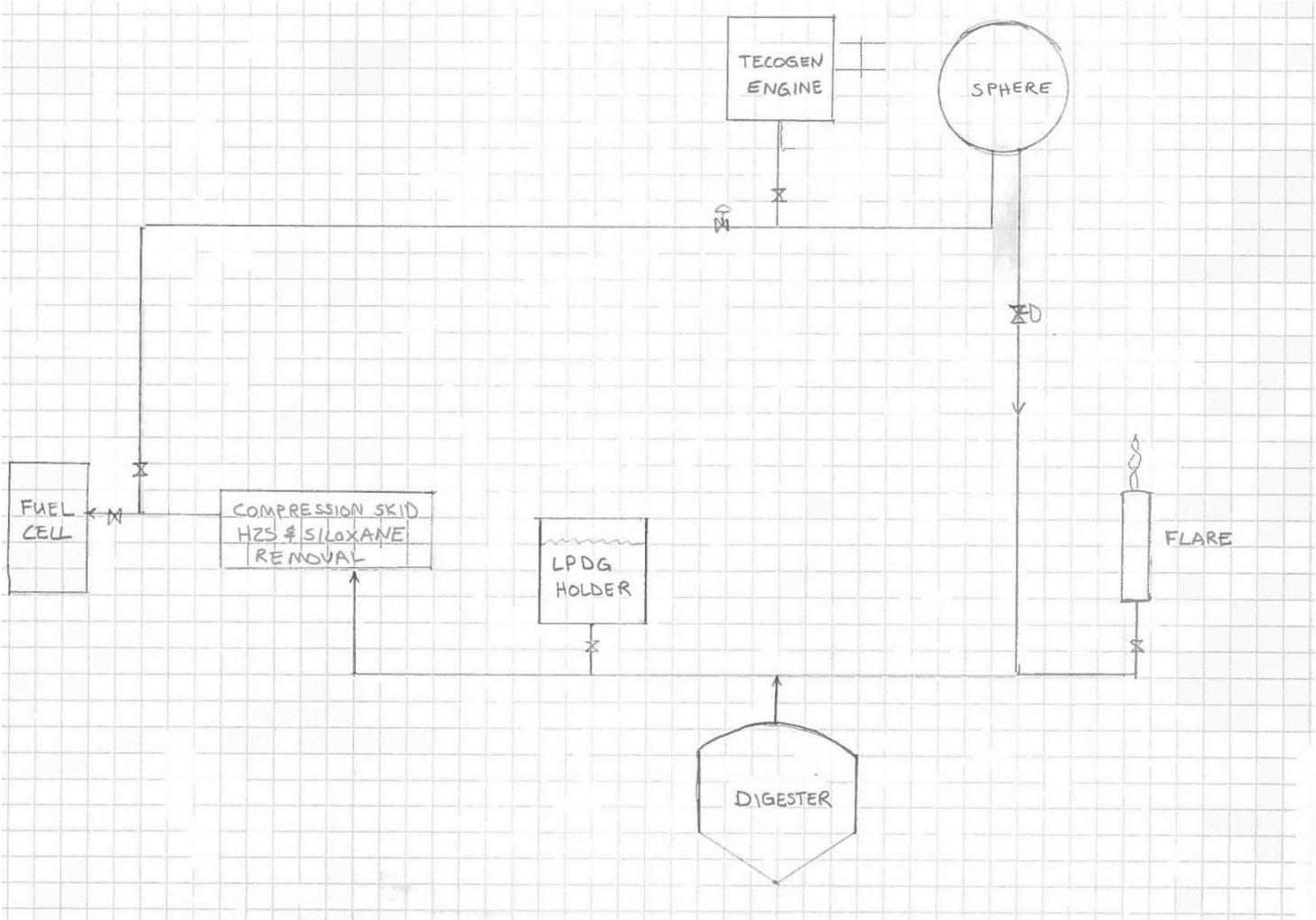
- Make use of sites DG conditioning system that had been installed for fuel cells
- Direct conditioned DG to blower engine
- Goal: 6552 hour life for secondary catalyst with compliant emissions
- Started operation in late August 2015

MVRWRF Digester Gas Tecogen Project



MVRWRF DG ENGINE PROCESS FLOW DIAGRAM (TECOGEN/Digester Gas)

Tecogen System in Context of Plant



MVRWRF Digester Gas Tecogen Project



- 700 HP
- Caterpillar G398-TA-HCR, turbocharged
- Rich burn, digester gas blower engine
- Altronic EPC 100 AFRC



700 HP, Caterpillar G398-TA-HCR



MVRWRF Digester Gas Conditioning



Inlet Sampling Location

Outlet Sampling Location

MVRWRF Digester Gas Conditioning

- Two H₂S removal vessels in series, Applied Filter Technology, 24,960 lb media, activated carbon impregnated with iron sponge
- Two compressors
- Refrigerated condenser removes moisture
- Two siloxane removal vessels in series, Applied Filter Technology, 2300 lb media, graphite



MVRWRF Tecogen



MVRWRF Tecogen - Close Up



Underside of Heat Exchangers



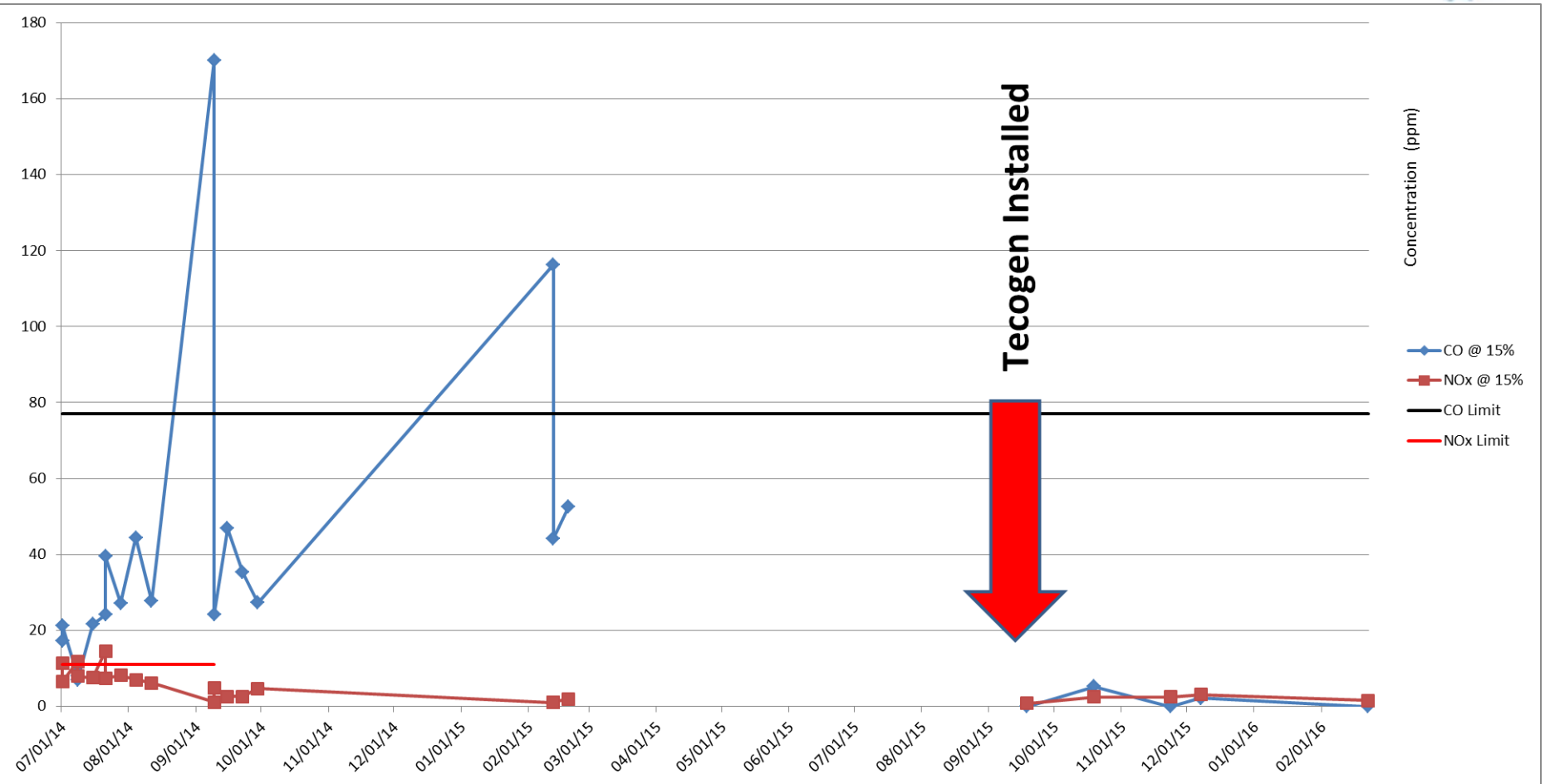
MVRWRF Tecogen Installation



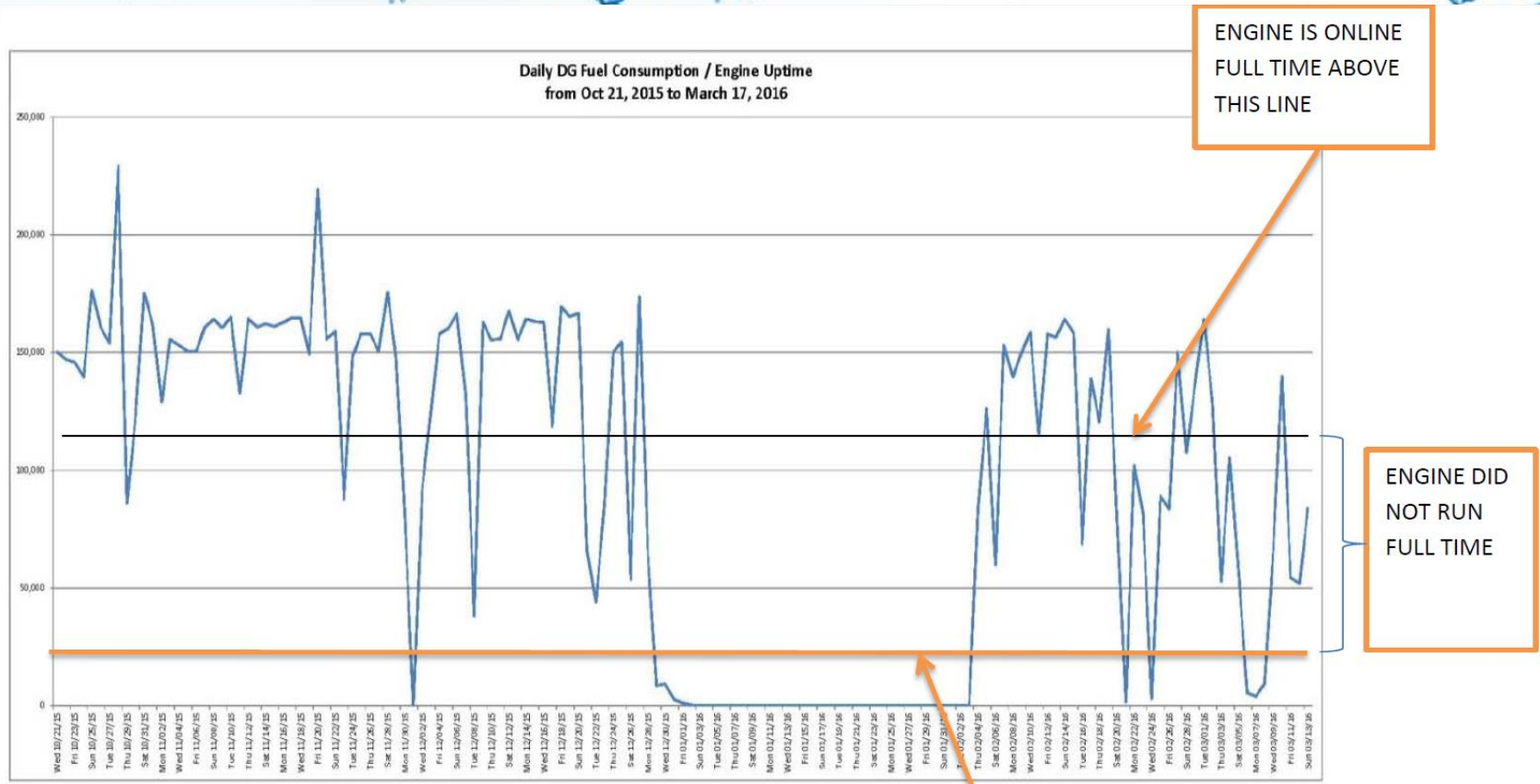
Heat exchange loops



MVRWRF DG Engine PA Results



MVRWRF DG Fuel Usage



Engine uptime and daily DG fuel consumption

Potential Benefits - Periodic Testing



- Stay on Monthly vs. Weekly test schedule. Test every 750 hours vs. 150 hrs. (5X difference) Fewer tests needed.



- Fewer portable test fails. Fewer re-tests. Less testing labor.



Potential Benefits - More Benefits



- Compliance at low loads and during mechanical issues.
- Operational flexibility. Compliance at low suction pressure. Allow pumping in opposite directions.
- Confidence in compliance.
Buffer below permit limits.
- Avoid overtime costs from evening and weekend call-outs for alarms. Avoid work interruptions from responding techs.
- Leadership in engine control technology & compliance.



Potential Benefits - Better Than Alternatives



- Avoid reliance on fuel cells or large NOx reactor or SCR
- Recover investment in digester gas conditioning system for fuel cells
- Avoid flaring of digester gas
- Protect capital investment in engines



Potential Issues with Tecogen

- First generation system. Better equipment/design later?
- Adds more equipment. Adds second catalyst that will eventually need replacement.
- HX damaged when power goes out or no circulation?
- Potential for damage to catalysts.



Declare Energy Independence??



I Want **You** For
Energy Independence



- EASTERN MUNICIPAL WATER DISTRICT

Contact Information

C. Corliss

Air Quality Compliance Analyst II

Questions?

Engine Emission Levels



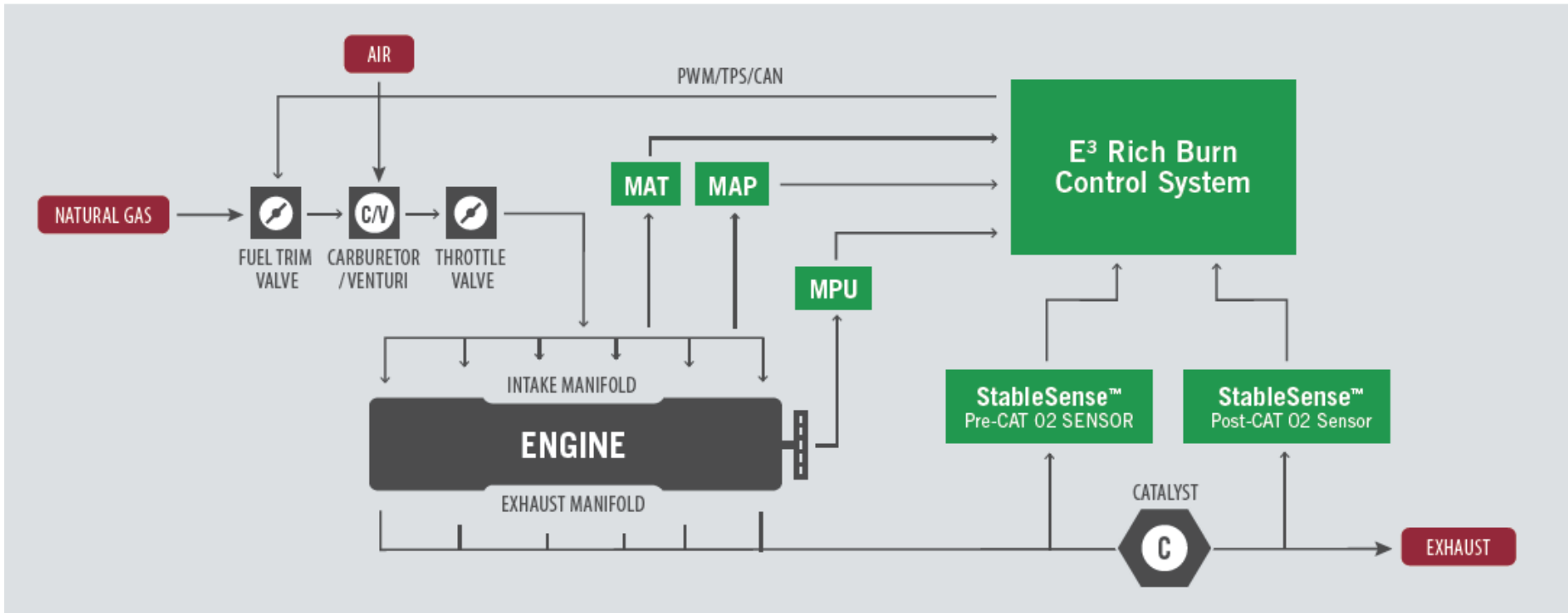
	CARB 07 (DG) Certification Program			SCAQMD (DG Applications – Rule 1110.2)			SCAQMD / SJVAPCD Engine BACT		
	NOx	CO	VOC	NOx	CO	VOC	NOx	CO	VOC
Lb/MW-hr	0.07	0.1	0.02	0.07	0.2	0.1			
ppmvd @15%O2 (0% CHP Heat Recovery Credit)	1.8	4.0	1.4	1.8	8.0	6.9			
ppmvd @15%O2 (40% CHP heat Recovery Credit)	3.7	8.0	2.7	3.7	16.0	13.7			
ppmvd@15%O2							11	70	30
Gr/Bhp-hr	0.023			0.023			0.15	0.6	0.15

Woodward E3 Trim System



- Uses oxygen sensors designed for natural gas engines
 - Not affected by methane like auto sensors
- Dithers the AFRC
- Integrates AFRC, speed controller and ignition controller
- EMWD installed one in 2010

Woodward E3 Trim System



Cat G3412NA, 365 HP, Rich burn, NG



Portable Analyzer Test Results - Woodward E3 Trim

