

ENVIRONMENTAL
SOLUTIONS, INC.

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ENGINE SOURCE TEST REPORT

OUTSIDE OPERATIONS, INC.
2050 HIGHWAY 118
MIRAMONTE, CALIFORNIA
93276

VEHICLE TYPE: HEAVY TRUCK

UNITS TESTED:

K-43 LTR-8
APCD #009-0008

DATE TESTED:

APRIL 16, 1991

DATE REPORTED:

MAY 13, 1991

TEST DETERMINATIONS:

EMISSIONS OF CO, HC AND O₂

REPORT NO. 10-552

TESTED BY: *E. W. Z...*

EEIC 22211

REVIEWED BY: *[Signature]*

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RECEIVED
MAY 14 1991
ENVIRONMENTAL

RECEIVED
MAY 29 1991
KERN COUNTY AIR
POLLUTION CONTROL DIST.

SUMMARY OF SOURCE TEST RESULTS

COMPANY: BECHTEL PETROLEUM OPERATIONS, INC.

APCD #: 4091020B

TEST DATE: APRIL 16, 1991

UNIT #: K-43 LTS-2

EMISSIONS

	gr/scf	@12% CO2	ppm	3% O2	lb/hr	g/BHP-hr	Permit Limits
PARTICULATE							
Mean:							
SULFATE							
Mean:							
SO2 (wet)			Total Sulfur As H2S, <1.0 ppm				
Mean:							
NOx (dry)			56.66	121.80	2.28	0.54	8.82 lbs/hr 2.00 g/BHP-hr
			57.40	120.70	2.33	0.54	
			<u>59.03</u>	<u>125.60</u>	<u>2.41</u>	<u>0.57</u>	
Mean:			57.70	122.70	2.34	0.55	
NMHC							
Mean:							
CO							
Mean:							

Comments: ANNUAL 210.1 - 2000 Hp GASFW PCC
RETEST - FAILED NOx Test of 4/15/91

For Kern County Use Only: DAH 6-6-91

SUMMARY OF SOURCE TEST RESULTS FOR EPA

COMPANY: BECHTEL PETROLEUM OPERATIONS, INC.

PERMIT: NSR 4-4-8 SJ7742

UNIT# OR NAME: K-43

LOCATION: LTS-2

Pollutant/Other	Test Method	Test Date	Emission/Other*	
			Test Results	Permit Limits
Particulate				
Sulfur Dioxide				
NOx as NO2	CARB 1-100	4-16-91	0.55 g/BHP hr	2.00 g/BHP hr
Carbon monoxide				
Hydrocarbons				
Sulfur Content				
Fuel Usage				
Excess Oxygen				

*Emissions are corrected to EPA standard conditions (68°F and 29.92 inches of Hg) and in units of EPA's permit.

Prepared by: Eric Charles

Title: Project Supervisor

Date: April 16, 1991

INTRODUCTION

INTRODUCTION

On April 16, 1991, Petro Chem Environmental Services, Inc. (PCES) performed a series of source tests for Bechtel Petroleum Operations, Inc. at the Elk Hills Naval Petroleum Reserve located in Tupman, California. The unit tested was a 2000 hp Ingersoll-Rand Internal Combustion Engine (K-43 LTS-2) fired on natural gas. The purpose of the testing was for determination of compliance with Kern County APCD and EPA regulations. Emissions of NO_x and O₂ were determined using the following procedures:

Parameter	Method	# Runs
NO _x	TECO Chemiluminescent NO/NO _x Analyzer	3 - 40 min.
O ₂	Micro Fuel Cell Analyzer	3 - 40 min.
Fuel Analysis, Fuel Sulfur	ASTM D-3588 H ₂ S by Microcoulometer	1 per site
DSCFM	Fuel Flow/Fuel Analysis Stoichiometric Calculations	3

All sampling was performed by Eric Charles of Petro Chem Environmental Services, Inc. All fuel analysis was performed by Pacific Gas Technology of Bakersfield, California. Mike Carr of Bechtel Petroleum Operations, Inc. supervised the operation of the test unit.

INSTRUMENT DATA

COMPANY : BECHTEL PETROLEUM OPERATIONS, INC.
 UNIT : K-43 LTS-2
 DATE : 4-16-91
 REPORT : 10-592A

NOx/O2 DATA
RUN #1

TIME INTERVAL		CONCENTRATIONS		% Full Scale	
BEGIN	END	O2;%	NOx;ppm	O2%fs	NOx%fs
07:05 AM	07:15 AM	12.46	55.76	60	21.1
07:15 AM	07:25 AM	12.59	53.34	60.6	20.6
07:25 AM	07:35 AM	12.63	57.93	60.8	21.5
07:35 AM	07:45 AM	12.61	59.60	60.5	21.9
Averages:		12.57	56.66	60.48	21.28

	O2	NOx
INITIAL zero	9.5	10
INITIAL span	94.1	91.8
FINAL zero	9.9	10
FINAL span	94.2	91.9
ZERO DRIFT %/ppm:	0.098817	0
CALIB. DRIFT %/ppm:	0.024704	0.50
ZERO DRIFT %fs:	0.4	0
CALIB. DRIFT %fs:	0.1	0.1
CAL GAS value	20.9	410
FULL SCALE RANGE	25	500

Meter Positive	8.5	MCF/Day 329.37
Meter Static	7.75	DSCFM 5542.5
Meter Coefficient	0.005	
MMBtu/SCF	0.001128	
F°60	8555.345	
Operating BHP	1927	

NOx	%O2	ppm	@ 3%O2	@15%O2	lb/hr	gr/BHP-hr
	12.57	56.66	121.80	40.14	2.28	0.54

COMPANY : BECHTEL PETROLEUM OPERATIONS, INC.
 UNIT : K-43 LTS-2
 DATE : 4-18-91
 REPORT : 10-592A

NOx/O2 DATA
 RUN #2

TIME INTERVAL		CONCENTRATIONS		% Full Scale	
BEGIN	END	O2;%	NOx;ppm	O2%fs	NOx%fs
07:50 AM	08:00 AM	12.39	62.83	60	22.5
08:00 AM	08:10 AM	12.37	61.16	60	22.2
08:10 AM	08:20 AM	12.35	54.98	60	21
08:20 AM	08:30 AM	12.44	50.65	60.1	20
Averages:		12.39	57.40	60.03	21.43

	O2	NOx
INITIAL zero	10	9.9
INITIAL span	94.2	91.8
FINAL zero	10	10
FINAL span	93.8	91.7
ZERO DRIFT %/ppm:	0	0.50061
CALIB. DRIFT %/ppm:	-0.09928	-0.50
ZERO DRIFT %fs:	0	0.1
CALIB. DRIFT %fs:	-0.4	-0.1
CAL GAS value	20.9	410
FULL SCALE RANGE	25	500

Meter Positive	8.75	MCF/Day 339.06
Meter Static	7.75	DSCFM 5582.6
Meter Coefficient	0.005	
MMBtu/SCF	0.001128	
F°60	8555.345	
Operating BHP	1964	

NOx	%O2	ppm	@ 3%O2	@15%O2	lb/hr	gr/BHP-hr
	12.39	57.40	120.70	39.79	2.33	0.54

PETRO CHEM ENVIRONMENTAL SERVICES, INC.

COMPANY : BECHTEL PETROLEUM OPERATIONS, INC.
 UNIT : K-43 LTS-2
 DATE : 4-16-91
 REPORT : 10-592A

NOx/O2 DATA
RUN #3

TIME INTERVAL		CONCENTRATIONS		% Full Scale	
BEGIN	END	O2;%	NOx;ppm	O2%fs	NOx%fs
08:35 AM	08:45 AM	12.47	63.11	60	22.5
08:45 AM	08:55 AM	12.44	60.85	59.9	22
08:55 AM	09:05 AM	12.54	54.07	60.3	20.6
09:05 AM	09:15 AM	12.48	58.09	60	21.6
Averages:		12.49	59.03	60.05	21.68

	O2	NOx
INITIAL zero	9.9	10
INITIAL span	93.8	91.7
FINAL SPAN	10	9.9
FINAL span	93.8	91.9
ZERO DRIFT %/ppm:	0.024910	-0.5018
CALIB. DRIFT %/ppm:	0	1.00
ZERO DRIFT %fs:	0.1	-0.1
CALIB. DRIFT %fs:	0	0.2
CAL GAS value	20.9	410
FULL SCALE RANGE	25	500

Meter Positive	8.7	MCF/Day 337.12
Meter Static	7.75	DSCFM 5814.9
Meter Coefficient	0.005	
MMBtu/SCF	0.001128	
F°60	8555.345	
Operating BHP	1931	

NOx	%O2	ppm	@ 3%O2	@15%O2	lb/hr	gr/BHP-hr
	12.49	59.03	125.60	41.39	2.41	0.57

PETRO CHEM ENVIRONMENTAL SERVICES, INC.

CONTINUOUS EMISSION MONITORING SYSTEM (CEMS)

Reference: BAAQMD, Manual of Procedures; ST-13A, ST-19A, Jan 1982, State of California, Air Resources Board, Test Methods 1-100, June 1979.
EPA CFR Title 40, Pt. 60, Appendix A, Method 20.

Instrument Summary

A constant sample of flue gas was extracted, dried, filtered and delivered to an instrument manifold system for distribution to one or more analyzers. Instrument results are recorded on an analog strip chart recorder. System calibration checks are performed as well as calibration checks at the beginning and end of each test run. Final data reduction includes zero and calibration drift corrections.

Sample Conditioning System

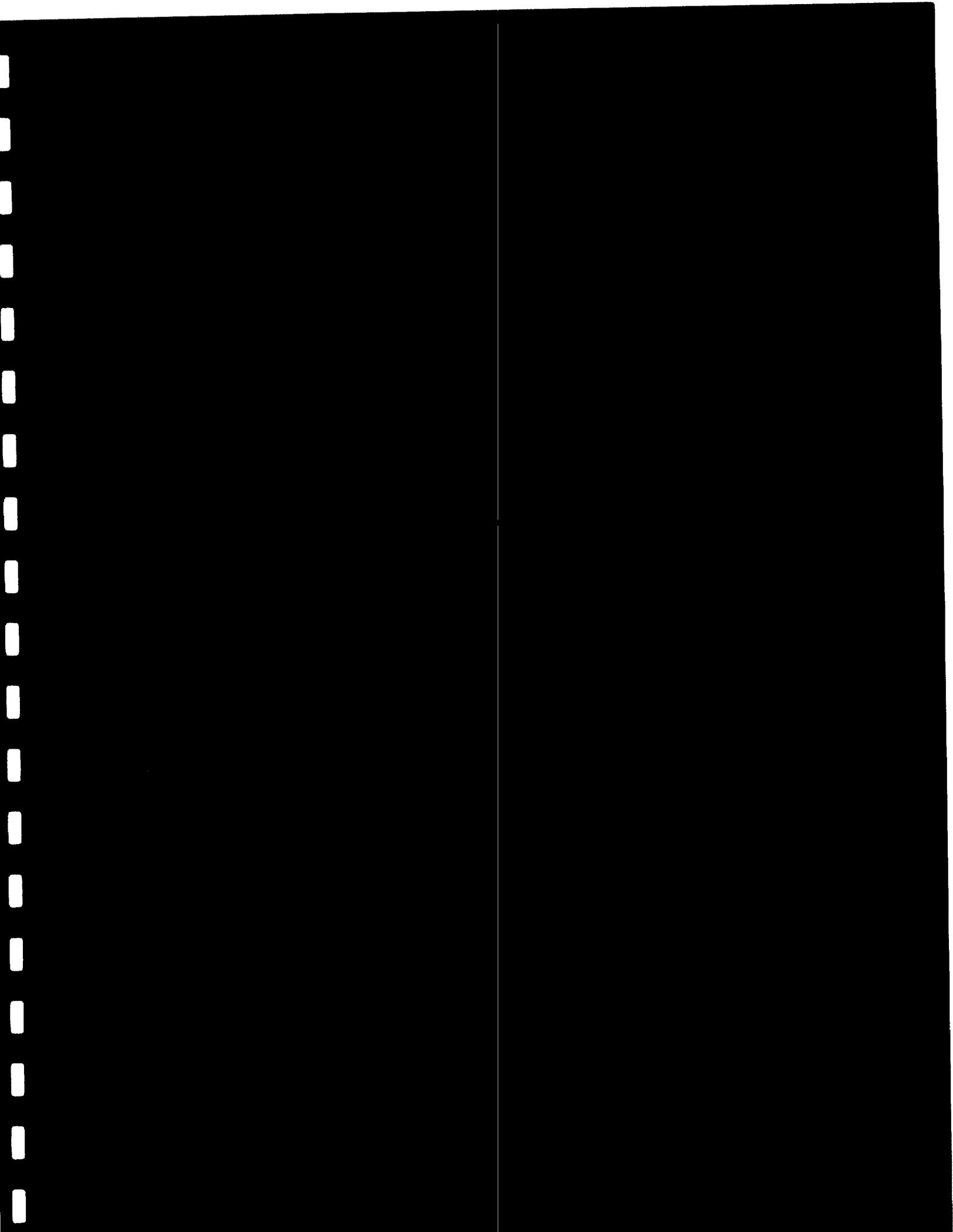
Consists of a borosilicate glass tube or 316 grade stainless steel probe fitted with a cindered stainless steel or pyrex glass wool particulate filter. The probe is fitted with a teflon (TFE) sample line which connects to a water condensation system located at the sources. The condensation system consists of three 500-ml short stem glass impingers connected in a series, immersed in an ice bath. The gas is delivered to the instrument trailer with a teflon line (3/8" O.D.) through an in-line Balstron particulate filter drawn by a teflon-coated diaphragm pump. The sample system is leak checked prior to sampling by plugging the end of the sample probe and adjusting the sample pump to its maximum rate (approximately 22" Hg). The manifold is by-passed and the leak rate monitored through a gas meter or low range flow meter.

Manifold System

Sample gas is delivered to each analyzer through a five way valve and regulated with a needle valve flow meter. Manifold pressure is controlled by a back pressure regulator which is typically set at three psi. Zero gas (N_2) and calibrated gases are delivered to the analyzers using the same five way valve and flow meter. All manifold parts are glass, stainless steel, or teflon materials.

Analog Strip Chart Data Reduction

Analog recordings consists of averaged time increments as shown on the data pages (typically 5, 10, or 20 minute increments). Data for each increment was recorded at an average percent of full scale. The readings were then compared with the zero and calibration readings for calculation of the average concentration for each time increment. Any deviation of the zero and calibration readings from the start to the end of a test period was corrected by calculating apparent zero and calibration readings for the mid-point of each time increment. The average concentrations were then calculated from the sample readings and the apparent zero and span readings.



COMPANY : BECHTEL PETROLEUM OPERATIONS, INC.
 UNIT : K-43 LTS-2
 DATE : 4-16-91
 REPORT : 10-592A

EPA 'F' FACTOR FOR FUEL GAS

FUEL COMPONENT	C	H	EXPANSION FACTOR	COMPONENT MOLE %	EXHAUST DSCF (0)/ SCF FUEL
METHANE	1	4	8.57	84.1	7.20737
ETHANE	2	6	15.25	8.41	1.282525
PROPANE	3	8	21.92	4.25	0.9316
(ISO-BUTANE)	4	10	28.6	0.17	0.04862
NORM-BUTANE	4	10	28.6	0.31	0.08866
(ISO-PENTANE)	5	12	35.28	0.03	0.010584
NORM-PENTANE	5	12	35.28	0.03	0.010584
HEXANE +	6	14	41.95	0.12	0.05034
AIR (N2+O2)	—	—	1	0.44	0.0044
CO2	—	—	1	2.14	0.0214
H2S	—	—	6.68	0	0
			TOTAL	100	9.656083

<u>9.656083</u>	DSCF EXHAUST PER SCF OF FUEL GAS AT ZERO % OXYGEN
<u>1020.9846</u>	NET BTU/SCF OF FUEL GAS
<u>1128.6608</u>	GROSS BTU/SCF OF FUEL GAS
<u>8555.3450</u>	DSCF/MMBTU (EPA 'F' FACTOR @ 60°F & ZERO % OXYGEN)
<u>8685.6294</u>	DSCF/MMBTU (EPA 'F' FACTOR @ 68°F & ZERO % OXYGEN)

PACIFIC GAS TECHNOLOGY



4200 Easton Drive - Suite 5
 Bakersfield, California 93309
 805/324-1317
 Fax: 805/324-2746

GAS ANALYSIS BY CHROMATOGRAPH

PETROCHEM ENVIRONMENTAL SERVICES
 3207 Antonino Avenue
 Bakersfield, CA 93308

Attention: Faythe Blythe

Sample ID : BECHTEL
 UNITS K-40, K-43
 FUEL GAS

JOB NUMBER : 10-592

SAMPLED: APRIL 16, 1991

SUBMITTED: APRIL 16, 1991

REPORTED: APRIL 26, 1991

LAB # 2101-1

CUSTOMER
 NUMBER : 02067

ANALYZED GAS

	MOLE %	WT %	CHONS	WT %
OXYGEN	0.05	0.08	CARBON	73.57
NITROGEN	0.39	0.56	HYDROGEN	22.25
CARBON DIOXIDE	2.14	4.86	OXYGEN	3.61
HYDROGEN	ND	0.00	NITROGEN	0.56
CARBON MONOXIDE	ND	0.00	SULFUR	0.00
METHANE	84.10	69.59		
ETHANE	8.41	13.04		
PROPANE	4.25	9.67		
iso-BUTANE	0.17	0.51		
n-BUTANE	0.31	0.93		
iso-PENTANE	0.03	0.11		
n-PENTANE	0.03	0.11		
HEXANE +	0.12	0.53		

SPECIFIC GRAVITY * : 0.669

HYDROGEN SULFIDE : ppm
 (Draeger)

TOTAL * DRY : 1131
 BTU/cu ft

WET : 1111

BTU/lb : 22272

SPECIFIC
 VOLUME : 19.69 cu ft/lb

TOTAL SULFUR

As H₂S : ND < 1.0 ppm(vol)

* CALCULATED ACCORDING TO :
 ASTM D-358

F-FACTOR FOR GASEOUS FUELS

Ref: 1) Code of Federal Regulations 40 CFR 60.45
2) Handbook of Chemistry and Physics; CRC Press

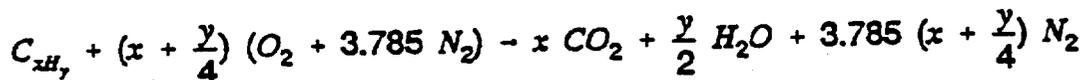
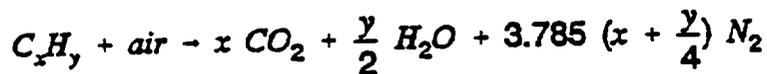
The F-Factor is the ratio of the total exhaust volume (DSCF^{*}) produced by the stoichiometric combustion of 1 SCF of the gaseous fuel and the Btu content of the same 1 SCF of gaseous fuel.

$$\text{EPA F Factor} = F \frac{\text{DSCF}^{\circ}}{\text{MMBtu}} = 10^6 \times \frac{\frac{\text{DSCF}^{\circ}}{\text{SCF fuel}}}{\frac{\text{Btu}}{\text{SCF fuel}}}$$

STOICHIOMETRIC COMBUSTION OF HYDROCARBONS:

The exhaust volume concentration of each fuel gas component is determined by the general equation for the stoichiometric combustion of a gaseous hydrocarbon.

C_xH_y in air:



Therefore, for each mole (or standard cubic foot) of each fuel gas component C_xH_y , there will be:

1) $x + \frac{y}{2} + 3.785 \left(x + \frac{y}{4}\right)$ moles (or SCF) of "wet" exhaust flow

2) $x + 3.785 \left(x + \frac{y}{4}\right)$ moles (or DSCF) of "dry" exhaust flow

OR

1 SCF of C_xH_y produces $4.785x + 0.946y$ DSCF^{*} flue gas

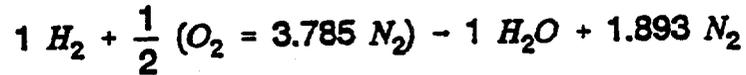
where: x = # of carbon atoms in component C_xH_y
 y = # of hydrogen atoms in component C_xH_y

If non-combustible components such as N_2 , O_2 , or CO_2 are present in the gaseous fuel, these will not participate in the combustion process.

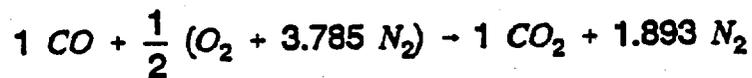
1 SCF Non-combustible component produces 1 SCF^{*} flue gas.

STOICHIOMETRIC COMBUSTION OF HYDROCARBONS (con't)...

Hydrogen (H₂) combustion proceeds according to the reaction:



Carbon Monoxide (CO) combustion in air proceeds according to the reaction:



1 SCF CO produces 2.893 DSCF° flue gas

The total exhaust gas volume at stoichiometric combustion (zero % excess O₂) is the summation of the individual component's contribution. The actual total exhaust gas volume is greater and depends on the % O₂ in the exhaust gas.

$$\text{Actual DSCF} = \text{DSCF}^\circ \text{ (@ stoichiometric combustion)} \times \frac{20.9}{20.9 - \% O_2 \text{ in exhaust gas}}$$

BTU HEATING CONTENT OF GASEOUS FUELS:

The Btu/SCF of the gaseous fuel is determined either by actual measurement of a sample combustion in a calorimeter or from a summation of the known heating value of the components multiplied by the mole fraction of the components.

FIELD DATA

INTERNAL COMBUSTION ENGINE
SOURCE TEST DATA

DEPT 640

A

B

DATE 4-16-91

COMP NO.	K-43	—	—	K 40			
LOCATION	LTS-2	—	—	LTS-2			
START TIME	7:05	7:50	8:35	9:45	10:25	11:10	
END TIME	7:45	8:30	9:15	10:25	11:05	11:50	

FUEL GAS METER DATA

COEFFICIENT	.005	—	—	.016			
STATIC	7.75	7.75	7.75	7.7	7.7	7.7	
DIFF.	8.5	8.75	8.7	8.7	8.7	8.7	
MCF/D	329	339	337	702	702	702	

^{K45} REF772 on gear for Today COMPRESSOR OPERATION PARAMETERS

SUC PRESS.	6/53	4.5/53	5.75/53	360	370	360	
DISCH PRESS.	400	390	400	2850	2850	2900	
RATED HP.	2000	—	—	5500	—	—	
TESTED HP.	1927	1954	1931	4558	4670		
% LOAD	96	97	97	83	84		
RPM	319	320	319	343	338	342	
SPARK AIR-MANIFOLD PRESS.	12.0	12.0	12.0	15.5	14.7	15.3	
GAS PRESS.	9.75	10.4	10.0	30.6	32.2	31.5	
	19.5	20.3	19.6	30.6	32.4	31.5	

PRELIMINARY SOURCE TEST DATA (IN GR/BHP-HR AND LBS-HR)

EF GAS	9.6	—	—	9.6	—	—	
O2 %	12.5	12.5	12.5	14.75	14.75	14.8	
DSCFM	5463	5624	5592	15910			
PPM NOX	55	60	60	9	7	11	
LBS-HR NOX	2.19	2.45	2.44	1.04			
GR/BHP-HR	.51	.57	.57	.10			
PPM CO							
LBS-HR CO							
GR/BHP-HR							

QUALITY ASSURANCE

REPORT OF ANALYSIS

CUSTOMER ORDER NUMBER: 89-000-00408

CYLINDER NUMBER <u>CC65124</u>		CYLINDER NUMBER _____	
COMPONENT	CONCENTRATION(v/v)	COMPONENT	CONCENTRATION(v/v)
Nitric Oxide	410 ± 4 ppm	Replicate 9/13/89	409 ppm
		Analysis	408 ppm
Carbon Monoxide	25.27 ± 0.25 ppm	Data On	<u>410 ppm</u>
		NO: Mean	<u>409 ppm</u>
Nitrogen	Balance		<u>410 ppm</u>
Cylinder Pressure: 2000 psig		Expiration Date NO: 3/20/90	

CYLINDER NUMBER <u>CC65124</u>		CYLINDER NUMBER _____	
COMPONENT	CONCENTRATION(v/v)	COMPONENT	CONCENTRATION(v/v)
		Replicate 9/12/89	25.34 ppm
		Analysis	25.36 ppm
		Data On	<u>25.34 ppm</u>
		CO: Mean	<u>25.35 ppm</u>
			9/19/89 25.10 ppm
			25.30 ppm
			<u>25.13 ppm</u>
			<u>25.18 ppm</u>
		Expiration Date CO: 3/19/90	

CYLINDER NUMBER <u>CC65124</u>		CYLINDER NUMBER _____	
COMPONENT	CONCENTRATION(v/v)	COMPONENT	CONCENTRATION(v/v)

(The Nitric Oxide analysis was performed in accordance with Section 3.0.4 of the)
 (revised EPA traceability protocol No. 1 dated June 9, 1987. The analysis is)
 (traceable to the National Institute of Standards & Technology by direct intercom-)
 (parison with GMIS, cylinder number CC37810 at 508 ppm Nitric Oxide in Oxygen Free)
 (Nitrogen. The analysis was performed using a Monitor Labs Model 8440, S/N 136)
 (analyzer with continuous chemiluminescence detection. The last multipoint)
 (calibration was performed 9/9/89.)

CYLINDER NUMBER <u>CC65124</u>		CYLINDER NUMBER _____	
COMPONENT	CONCENTRATION(v/v)	COMPONENT	CONCENTRATION(v/v)

(The Carbon Monoxide analysis was performed in accordance with Section 3.0.4 of the)
 (revised EPA traceability protocol No. 1 dated June 9, 1987. The analysis is)
 (traceable to the National Institute of Standards & Technology by direct intercom-)
 (parison with GMIS, cylinder number CC66863 at 42.2 ppm Carbon Monoxide in)
 (Ultrapure Air. The analysis was performed using a Carle Model 8000 gas chromato-)
 (graph with catalytic methanation/flame ionization detection. The last multipoint)
 (calibration was performed 9/16/89.)

MENT STRIP CHART

