Note: This material is related to a section in *AP42, Compilation of Air Pollutant Emission Factors, Volume I Stationary Point and Area Sources.* AP42 is located on the EPA web site at www.epa.gov/ttn/chief/ap42/

The file name refers to the file number, the AP42 chapter and then the section. The file name "rel01_c01s02.pdf" would mean the file relates to AP42 chapter 1 section 2. The document may be out of date and related to a previous version of the section. The document has been saved for archival and historical purposes. The primary source should always be checked. If current related information is available, it will be posted on the AP42 webpage with the current version of the section.

State of Kansas
Joan Finney, *Governor*

Department of Health and Environment
Azzie Young, Ph.D., *Secretary*

Reply to: (913) 296-1580

3.4

May 11, 1992

Michael Chan
Acurex Environmental
555 Clyde Avenue
Mt. View, California 94043

Dear Mr. Chan:

In response to your telephone conversation with L. C. Hinther, enclosed is a brief summary and results of the Chanute Power Plant emissions test. If this information does not suffice, contact me with any additional data/information you may need.

Sincerely,

Michael J. Parhomek
Environmental Technician
Bureau of Air and Waste Management

tam:Chan

Gaseous Emissions Compliance Test Report

for the

City of Chanute, Kansas

at their

Power Plant No. 3

September 1991
91-302-3

Introduction

This report presents the results of the gaseous emission compliance testing performed for the city of Chanute, Kansas at their Power Plant No. 3 facility located in Chanute, Kansas.

The purpose of the testing was to determine the NO_x emission rates from one of the three Fairbanks-Morse Colt Piekstick - duel fueled engines and one of the two Fairbanks-Morse Colt Piestick - diesel fueled engines at Chanute's Power Plant No. 3.

The testing was performed by Burns and McDonnell Engineering Company whose main office is located at 4800 East 63rd Street, Kansas City, Missouri 64141. On September 4, 1991 the NO_x emission testing was performed on Engine No. 12, operating at 50%, 75% and 100% loads, conducting three tests for each load. On September 5, 1991 the NO_x emission testing was performed on Engine No. 11, operating at 60%, 75% and 100% loads, conducting three tests for each load. The testing was performed in accordance with EPA Reference Methods 3A, 7E, 10 and 20 as published in the July 1, 1990 Code of Federal Regulations, Title 40, Parts 53 to 60 and Subpart FF "Standards of Performance for Stationary Internal Combustion Engines".

The testing equipment, sampling and analytical procedures are described in section IV of this report. The raw field data, equipment calibrations, lab analysis reports and equations used in determining the final results are presented in the Appendix.

The emission testing was coordinated by Mr. Fred Diehl - City Engineer and Mr. Jim Hutchison - Chief Operator. Burns and McDonnell's test crew consisted of: Russell Fowler (crew chief) and Luke Corkill (technician). Mr. Lynn Ranabargar from the State of Kansas Department of Health and Environment witnessed the compliance testing.

Summary of Test Results

The testing program for Chanute's Power Plant No. 3 consisted of performing three 30 minute test runs at each load point on Unit No. 11 and on Unit No. 12. On Unit No. 11, the established load points tested were: 4173 KW (60% load), 5216 KW (75% load) and 6955 KW (100% load). On Unit No. 12 the established load points tested were: 2763 KW (50% load), 4144 KW (75% load) and 5525 KW (100% load).

During the first part of the full load test on Unit No. 11, the cooling system for the turbo exhaust was not in operation, resulting in a steady increase in NO_x concentrations. After the cooling system was put into operation, a reduction of NO_x concentrations was recorded. Even though the NO_x emissions were slightly higher compared to normal operation, the unit was still in compliance. Therefore, retesting at this load point was not necessary.

While testing Unit No. 12, during Run 1 and Run 2, the CO monitor was not sending data to the computer data logger. There was a problem with an electrical connection and was resolved. Although, there are no charts plotted for CO during the test for Run 1 and Run 2, the data was recovered from the strip chart.

The following are tables summarizing the results of the gaseous emission tests performed on Chanute's Power Plant No. 3.

$\frac{5.9}{20.9 - O_2}$

Emissions Test Results for Unit No. 11

693 ppm proposed NSPS standard

Plant Load	Run #	NO_x (ppm) @ 15% O_2	NO_x (ppm) @ Ref Amb Cond	O_2 (%)	CO (ppm)
4173 KW	1	300	332	12.4	698
4173 KW	2	307	340	12.4	664
4173 KW	3	312	345	12.3	653
AVERAGE		306	339	12.4	672
5216 KW	1	312	339	12.3	513
5216 KW	2	311	337	12.3	582
5216 KW	3	325	352	12.3	555
AVERAGE		316	343	12.3	550
6955 KW	1	599	639	12.0	347
6955 KW	2	616	658	11.9	369
6955 KW	3	598	638	11.8	388
AVERAGE		604	645	11.9	368

Emissions Test Results for Unit No. 12

652 ppm proposed NSPS standard

Plant load	Run #	NO_x (ppm) @ 15% O_2	NO_x (ppm) @ Ref Amb Cond	O_2 (%)	CO (ppm)
2763 KW	1	514	551	12.6	134
2763 KW	2	519	556	12.7	146
2763 KW	3	530	568	12.7	163
AVERAGE		521	558	12.7	148
4144 KW	1	529	572	11.7	224
4144 KW	2	539	582	11.7	225
4144 KW	3	538	582	11.7	217
AVERAGE		535	579	11.7	222
5525 KW	1	536	569	11.0	300
5525 KW	2	533	566	11.0	285
5525 KW	3	544	577	11.1	296
AVERAGE		538	571	11.0	294

Following are the charts plotted from the computer data logger, listing the actual emission concentrations used in the calculations.

O_2 SAMPLING AND ANALYTICAL PROCEDURES METHOD 3A

Sampling Equipment

A Beckman Corporation portable compliance monitor Model 755 O_2 analyzer as shown in the exhibit, was used for the sampling of oxygen in the exhaust gas.

The sampling of the flue gas takes place via a porous filter connected to a T-type stainless steel heated probe. The sample is then transported to the analyzer via a self-regulating sample line constructed of reinforced tygon tubing. The sample is pulled by means of a Thomas diaphragm pump with the gas flow being regulated by a Dwyer flow rate meter.

Certified calibration gases are used to calibrate the analyzer. One span gas along with ambient air was used for the O_2 analyzer. The O_2 gases were based on a span value of 20.9 percent and were 80-100 percent range for the high level gas, 40-60 percent range for the mid level gas. NO_x calibration gas was used to zero the O_2 analyzer.

Interference gases were introduced into the analyzer prior to use in the field. Three interference gases were used, NO_x, CO and SO_2, for this particular test.

Sample Preparation

The sampling and conditioning portion of the system is designed to prevent los of O_2 from the sample gas as follows:

The sample is drawn through a heated, filtered probe to remove any particulate and condensation from reaching the monitor. A teflon sample line conveys the

sample gas to a sample conditioner at a temperature above the dew point of the sample, thereby preventing condensation and subsequent losses of soluble sample components. An ice bath sample conditioner, which is a simple form of a heat exchanger, completes the sampling conditioning. The object of this device is to reduce the temperature of the sample to a low enough level to allow the moisture in the sample to be regenerated in droplet form and to prevent condensation in the monitor.

The Beckman oxygen analyzer Model 755 provides a continuous readout of the oxygen content of the flowing gas sample. The determination is based on measurement of the magnetic susceptibility of the sample gas. Oxygen is strongly paramagentic; other common gases, with only a few exceptions, are weakly diamagnetic. With the Model 755, the volume magnetic susceptibility of the flowing gas sample is sensed in the detector/magnet assembly, which in turn displays the front panel reading on the analyzer, the output for the strip chart recordings and the output for the computer data logger.

Sampling Procedures

Sampling was conducted from the test port located in the stack. Prior to any sampling, the analyzer was set up by introducing the calibration gases one at a time and setting the appropriate span and zero values. This data was recorded on the corresponding strip charts and the computer data logger.

The probe was then positioned in the gas stream, heated at a controlled temperature (248^0F +/- 25^0F) and the sample pump turned on. Sampling time for

each run was 30 minutes (10 minutes at each point) including the system response time. The average steady-state concentrations of O_2 at the sample points was recorded on field test forms, recorded on the strip charts and recorded on the computer data logger. These data sheets can be found in the appendix. A post-test zero and calibration drift test was performed on the analyzer after each test run.

FIELD TEST DATA SHEET

Client Chanute

Project No. 91-302-3 Made By R. Fowler Date 9-4-91

Test Location Power Plant #3 Test No. 50% load

Sample Point	Time			% O_2	NOx PPM	CO PPM
engine # 12	10:45			12.5	710	155
50% Load	10:50			12.6	740	160
Run 1	10:55			12.6	705	160
65% Humidity	11:00			12.6	697	160
77° F	11:05			12.6	700	160
	11:10			12.6	708	158
	11:15					
Average						
Run 2	1130			12.6	725	172
65% Humidity	1135			12.6	730	170
50% Load	1140			12.6	740	170
79° F	1145			12.6	725	178
	1150			12.6	720	178
	1155			12.6	720	180
	1200			12.7	708	181
Average						
Run 3	1215			12.7	727	190
65% Humidity	1220			12.7	735	197
50% load	1225			12.7	740	195
80° F	1230			12.6	750	195
	1235			12.6	755	190
	1240			12.7	750	190
	1245			12.7	745	190
Average						

FIELD TEST DATA SHEET

Client Chanute

Project No. 91-302-3 Made By R. Fowler Date 9-4-91

Test Location Power Plant No 3 Test No. 75% Load

Sample Point	Time			% O_2	NOx PPM	CO PPM
engine #2	1310			11.7	803	245
75% Load	1315			11.7	825	247
Run 1	1320			11.6	835	247
60% Humidity	1325			11.7	840	258
81°F	1330			11.7	834	265
	1335			11.7	840	260
	1340			11.7	840	260
Average						
Run 2	1355			11.6	840	260
75% load	1400			11.7	840	255
60% Humidity	1405			11.6	833	260
83 °F	1410			11.6	835	259
	1415			11.5	848	258
	1420			11.5	848	250
	1425			11.6	834	247
Average						
Run 3	1445			11.7	840	250
75% Load	1450			11.7	830	248
60% Humidity	1455			11.7	830	240
83°F	1500			11.7	850	238
	1505			11.7	855	250
	1510			11.7	850	253
	1515			11.7	857	258

FIELD TEST DATA SHEET

Client Chanute

Project No. 91-302-3 Made By R. Fowler Date 9-4-91

Test Location Power Plant No 3 Test No. 100% Load

Sample Point	Time			% O_2	NO_X PPM	CO PPM
Engine #12	1535			11.0	905	340
Full load	1540			11.1	910	330
Run 1	1545			11.2	905	305
57% Humidity	1550			11.0	902	330
82 °F	1555			11.0	907	340
	1600			11.0	905	335
	1605			11.1	900	320
Average						
Run 2	1620			11.0	897	310
Full load	1625			11.0	905	310
57% Humidity	1630			11.0	915	310
83 °F	1635			11.0	910	318
	1640			11.0	910	320
	1645			11.0	910	330
	1650			11.0	920	325
Average						
Run 3	1700			11.0	920	320
Full load	1705			11.0	900	335
57% Humidity	1710			11.0	920	338
82 °F	1715			11.0	910	338
	1720			11.0	910	324
	1725			11.1	896	320
	1730			11.1	899	310
Average						

FIELD TEST DATA SHEET

Client Chanute

Project No. 91-302-3 Made By R. Fowler Date 9-5-91

Test Location Power Plant No 3 Test No. 100% Load

Sample Point	Time			% O_2	NO_X PPM	CO PPM
Engine # 11	0900			11.8	850	370
100% Load	0905			11.8	850	360
Run 1	0910			11.8	860	370
15% Humidity	0915			11.8	850	350
78 °F	0920			11.7	900	350
	0925			11.7	900	350
	0930			11.7	920	350
Average						
Run 2	0945			11.7	940	360
100% load	0950			11.8	930	370
15% Humidity	0955			11.7	930	375
80° °F	1000			11.8	920	370
	1005			11.7	950	365
	1010			11.7	960	350
	1015			11.7	960	360
Average						
Run 3	1030			11.7	990	400
100% Load	1035			11.8	980	420
15% Humidity	1040			11.8	875	435
85 °F	1045			11.8	850	440
	1050			11.8	850	440
	1055			11.8	875	440
	1100					
Average						

FIELD TEST DATA SHEET

Client Chanute

Project No. 91-302-3 Made By R. Fowler Date 9-5-91

Test Location Power Plant No. 3 Test No. 75% Load

Sample Point	Time			% O_2	NOx PPM	CO PPM
engine #11	1140			12.2	450	500
Run 1	1145			12.2	470	535
75% load	1150			12.2	460	540
55% Humidity	1155			12.2	460	540
87 °F	1200			12.2	470	500
	1205			12.2	463	580
	1210			12.2	460	600
Average						
Run 2	1220			12.2	455	590
75% Load	1225			12.2	460	585
55% Humidity,	1230			12.2	450	600
89 °F	1235			12.3	465	615
	1240			12.3	460	625
	1245			12.3	470	620
	1250			12.2	460	630
Average						
Run 3	1305			12.2	470	585
75% Load	1310			12.3	470	585
55% Humidity,	1315			12.3	465	585
89 °F	1320			12.3	475	580
	1325			12.2	475	585
	1330			12.3	465	590
	1335			12.3	467	585
Average						

FIELD TEST DATA SHEET

Client Chanute
Project No. 91-302-3 Made By R. Fowler Date 9-5-91
Test Location Power Plant No 3 Test No.

Sample Point	Time			% O_2	NO_X PPM	CO PPM
Engine #11	1345			12.4	435	735
Run 1	1350			12.3	430	730
100% Load	1355			12.3	430	735
60% Humidity	1400			12.4	430	725
87 °F	1405			12.3	435	725
	1410			12.3	430	725
	1415			12.4	430	725
Average						
Run 2	1430			12.3	435	690
100% Load	1435			12.4	430	700
60% Humidity	1440			12.4	425	690
89 °F	1445			12.3	430	690
	1450			12.3	425	700
	1455			12.3	420	695
	1500			12.3	430	685
Average						
Run 3	1510			12.3	440	690
100% Load	1515			12.3	435	685
Humidity	1520			12.3	450	680
88 °F	1525			12.3	440	680
	1530			12.3	440	690
	1535			12.3	435	695
	1540			12.3	445	690
Average						

KANSAS DEPARTMENT OF HEALTH AND ENVIRONMENT - VISIBLE EMISSION OBSERVATION FORM

SOURCE NAME: Chanute Municipal Power Plant

OBSERVATION DATE: Sept 4, 1991 | START TIME: 340 pm | STOP TIME: 346pm

ADDRESS: PO Box 907

Plant #3, 1/2 mi So Jct 35th & Plummer

CITY: Chanute | STATE: Kansas | ZIP: 66720

PHONE:

SOURCE ID NUMBER: 2560 00028

PROCESS EQUIPMENT: Engine - Generator | OPERATING MODE: On

CONTROL EQUIPMENT: | OPERATING MODE:

DESCRIBE EMISSION POINT: Exhaust Stack of Engine

HEIGHT ABOVE GROUND LEVEL: 44' | HEIGHT RELATIVE TO OBSERVER: 44'

DISTANCE FROM OBSERVER: 88' | DIRECTION FROM OBSERVER: Northeast

DESCRIBE EMISSIONS: Engine Exhaust - Unit #12

EMISSION COLOR: Light Brown | PLUME TYPE: CONTINUOUS ☒ FUGITIVE ☐ INTERMITTENT ☐

WATER DROPLETS PRESENT: NO ☒ YES ☐ | IS WATER DROPLET PLUME: ATTACHED ☐ DETACHED ☐

AT WHAT POINT IN THE PLUME WAS OPACITY DETERMINED: At Discharge

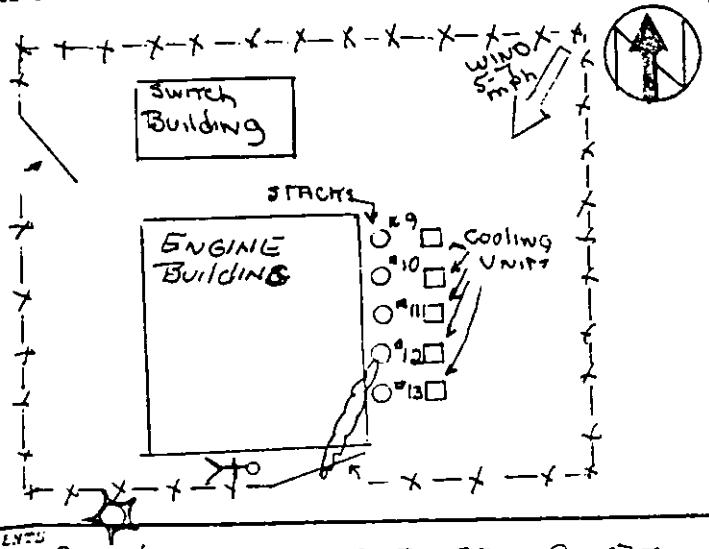
DESCRIBE BACKGROUND: Sky

BACKGROUND COLOR: Blue | SKY CONDITIONS: Cloudy - Partly

WIND SPEED: 5-7 mph | WIND DIRECTION: Northeast

AMBIENT TEMPERATURE: 82°F | RELATIVE HUMIDITY: 60%

SOURCE LAYOUT SKETCH — DRAW NORTH ARROW



M \ sec	0	15	30	45	M \ sec	0	15	30	45
1	5	5	5	5	31				
2	5	5	5	5	32				
3	5	5	5	5	33				
4	5	5	5	5	34				
5	5	5	5	5	35				
6	5	5	5	5	36				
7	5				37				
8					38				
9					39				
10					40				
11					41				
12					42				
13					43				
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21					51				
22					52				
23					53				
24					54				
25					55				
26					56				
27					57				
28					58				
29					59				
30					60				

AVERAGE OPACITY: 5% | NUMBER OF READINGS ABOVE: 20 & WERE 0

RANGE OF OPACITY READINGS: 5% MINIMUM 5% MAXIMUM

COMMENTS: In Compliance KAR 28-19-57

During Stack Test 100% Load

0% Opacity @ 50% 5% Opacity @ 75%

OBSERVER'S NAME (PRINT): Lynn Rainbarger

OBSERVER'S SIGNATURE: [signature] | DATE: Sept 4, 19

ORGANIZATION: KDHE - Air Quality

PERSON INTERVIEWED: Jim Hutchinson

TITLE: Power Generation Supervisor

VERIFIED BY: | DATE:

Acurex Environmental CORPORATION

555 Clyde Avenue
P.O. Box 7044
Mountain View, CA 94039
(415) 961-5700
FAX Numbers: (415) 964-6523, 964-5145

FAX COVER SHEET

TO

Name: Glenn Keller FAX No.: (312) 527-6658

Organization: EMA

Number of Pages Including Cover Sheet: 8

Date: 4/22/92 Time: 2:00 p.m.

FROM

Name: Michael Chan Ext.: 3700

MESSAGE

Glenn,

I forgot to ask you whether or not you have (or know of) any information on the estimated market share of the different sized engines and fuels in the U.S.

Could you also send/fax me a list of the manufacturers that you send this information to?

Thanks for your cooperation in this revision of AP-42.

Mike

FORM 4

Acurex Environmental

CORPORATION

April 22, 1992

Mr. Glenn Keller, Executive Director
Engine Manufacturers Association
401 N. Michigan Avenue
Chicago, Illinois 60611

Dear Mr. Keller,

Acurex Environmental Corporation is currently engaged in an update of Chapters 1 and 3 in the document Compilation of Air Pollutant Emission Factors (AP-42's Volume I: Stationary Point and Area Sources) for the US EPA's Office of Air Quality Planning and Standards (OAQPS). I am responsible for sections 3 and 4 of Chapter 3, entitled "Gasoline and Diesel Industrial Engines" and "Stationary Large Bore Diesel and Dual Fuel Engines" respectively. An emission factor is the quantity (mass) of pollutants emitted divided by a unit of activity (e.g., g/hp-hr of NO_X). The emission factors are used in making estimates of areawide emissions, emission estimates for a specific facility, and evaluation of emissions in relation to ambient air quality.

The primary emissions of interest are uncontrolled criteria pollutant emissions that are already listed in AP-42 (I have enclosed a copy of the current sections 3.3 and 3.4 of AP-42). EPA's OAQPS would also like to include any available data on Speciated VOC's, Air Toxics, Greenhouse Gases, Fugitive Emissions, and Particulate Sizing (PM_{10}) in this current update. As I mentioned, the current emission factors in AP-42 are based on uncontrolled data, but I would like to include a new table of emission factors that would be based on controlled data.

The data needs to include as much detail as possible to enable the rating of the data quality by EPA guidelines (I also enclosed a copy of the page on data quality rating). Preferably, the data would include the actual source tests and data sheets.

Currently, the stationary internal combustion reciprocating engines are divided by fuel used (gasoline, diesel, and dual fuel), rated power (20 to 250 hp for gasoline engines and 45 to 600 hp for diesel engines) in section 3.3, and bore size (greater than 560 cubic inch displacement per cylinder for diesel and dual fuel engines) for in section 3.4. It has been suggested to me that the engines should be sorted by the rated power and fuel used to make AP-42 easier to use. Therefore, I would like to be able to sort the data by fuel and horsepower (I have a preference for data on engines greater than 600 hp due to the scarcity of the data). I am open to any suggestions on improving the sections 3.3 and 3.4 in AP-42.

555 Clyde Avenue, P.O. Box 7044, Mountain View, CA 94039 (415) 961-5700 FAX: (415) 964-6523/5145

I am aware of the confidentiality of the data to the individual engine manufacturers, and if requested, I would reference the source of the data as from the Engine Manufacturers Association. The data for each rated power range (maybe grouped by 100 hp increments and fuel) will be averaged and weighted by the estimated market share before being published in the revised AP-42. Therefore, I am also interested in what the estimated existence or market share of stationary internal combustion reciprocating engines by rated power and fuel in the Unites States.

Because this phase of the update needs to be completed and published by June 1, 1992 for compliance with the Clean Air Act, I need to submit a draft of the revisions and supporting calculations by May 15, 1992. This puts a severe time constraint on my efforts, and any data that you can provide would be appreciated. If I can be of any assistance in collecting the information, please call me at (415) 961-5700, extension 3700.

Sincerely,

Michael J. Chan
Project Engineer
Acurex Environmental Corporation

Acurex
Environmental
CORPORATION

555 Clyde Avenue
P.O. Box 7044
Mountain View, CA 94039
(415) 961-5700
FAX Numbers: (415) 964-6523, 964-5145

FAX COVER SHEET

TO

Name: Steve Hill FAX No.: (415) 928-8560

Organization: Bay Area Air Quality Management District

Number of Pages Including Cover Sheet: 3

Date: 4/27/92 Time: 12:45

FROM

Name: Michael Chan Ext.: 3700

MESSAGE

Mr. Hill,

If you have any questions, please call me. I would like to come up with Carolyn as soon as possible.

Thanks,

Mike

Acurex Environmental

CORPORATION

April 27, 1992

Mr. Steve Hill
Bay Area Air Quality Management District
939 Ellis Street
San Francisco, CA 94109

Dear Mr. Hill,

This is a request for a date and time in which Carolyn Rushforth and myself can come up to Bay Area AQMD to find some emissions data. Acurex Environmental Corporation is currently engaged in an update of Chapters 1 and 3 in the document Compilation of Air Pollutant Emission Factors (AP-42's Volume I: Stationary Point and Area Sources) for the US EPA's Office of Air Quality Planning and Standards (OAQPS). Chapters 1 and 3 of AP-42 deals with stationary external and internal combustion sources.

The primary emissions of interest are uncontrolled criteria pollutant emissions that are currently listed in AP-42. EPA's OAQPS would also like to include any available data on Speciated VOC's, Air Toxics, Greenhouse Gases, Fugitive Emissions, and Particulate Sizing (PM_{10}) in this current update. The current emission factors in AP-42 are based on uncontrolled data, but a new table of emission factors that would be based on controlled data is desirable.

The data needs to include as much detail as possible to enable the rating of the data quality by EPA guidelines. Preferably, the data would also include the actual source test data.

In regard to Chapter 1, any air toxics data for any sized oil, coal, and/or LPG fired boilers is being requested.

555 Clyde Avenue, P.O. Box 7044, Mountain View, CA 94039 (415) 961-5700 FAX: (415) 964-6523/5145

In summary, the data that are being requested for a visit by Carolyn and myself is: (1) any emissions data (Criteria, Speciated VOC's, Air Toxics, Greenhouse Gases, Fugitive Emissions, and Particulate Sizing (PM_{10})) for all stationary internal combustion engines running on gasoline, diesel, or dual fuels; and (2) any air toxics data for any sized oil/coal/LPG fired boilers.

Because this phase of the update needs to be completed and published by June 1, 1992 for compliance with the Clean Air Act, I need to submit a draft of the revisions and supporting calculations by May 15, 1992. This puts a severe time constraint on my efforts, and any data that you can provide would be appreciated. Please call me at (415) 961-5700, extension 3700, to confirm a date and time for our visit to Bay Area AQMD.

Sincerely,

Michael J. Chan
Project Engineer
Acurex Environmental Corporation

Acurex Environmental
CORPORATION

555 Clyde Avenue
P.O. Box 7044
Mountain View, CA 94039
(415) 961-5700
FAX Numbers: (415) 964-6523, 964-5145

FAX COVER SHEET

TO
Name: Bob Nishimura FAX No.: (415) 749-5030
Organization: Bay Area AQMD
Number of Pages Including Cover Sheet: 3
Date: 4/28/92 Time: 9:00 A.M.

FROM
Name: Michael Chan Ext.: 3700

MESSAGE

Bob,

This is a copy of the letter that sent to Steve Hill yesterday.

Mike

Acurex Environmental

CORPORATION

April 27, 1992

Mr. Steve Hill
Bay Area Air Quality Management District
939 Ellis Street
San Francisco, CA 94109

Dear Mr. Hill,

This is a request for a date and time in which Carolyn Rushforth and myself can come up to Bay Area AQMD to find some emissions data. Acurex Environmental Corporation is currently engaged in an update of Chapters 1 and 3 in the document Compilation of Air Pollutant Emission Factors (AP-42's Volume I: Stationary Point and Area Sources) for the US EPA's Office of Air Quality Planning and Standards (OAQPS). Chapters 1 and 3 of AP-42 deals with stationary external and internal combustion sources.

The primary emissions of interest are uncontrolled criteria pollutant emissions that are currently listed in AP-42. EPA's OAQPS would also like to include any available data on Speciated VOC's, Air Toxics, Greenhouse Gases, Fugitive Emissions, and Particulate Sizing (PM_{10}) in this current update. The current emission factors in AP-42 are based on uncontrolled data, but a new table of emission factors that would be based on controlled data is desirable.

The data needs to include as much detail as possible to enable the rating of the data quality by EPA guidelines. Preferably, the data would also include the actual source test data.

In regard to Chapter 1, any air toxics data for any sized oil, coal, and/or LPG fired boilers is being requested.

555 Clyde Avenue, P.O. Box 7044, Mountain View, CA 94039 (415) 961-5700 FAX: (415) 964-6523/5145

In summary, the data that are being requested for a visit by Carolyn and myself is: (1) any emissions data (Criteria, Speciated VOC's, Air Toxics, Greenhouse Gases, Fugitive Emissions, and Particulate Sizing (PM_{10})) for all stationary internal combustion engines running on gasoline, diesel, or dual fuels; and (2) any air toxics data for any sized oil/coal/LPG fired boilers.

Because this phase of the update needs to be completed and published by June 1, 1992 for compliance with the Clean Air Act, I need to submit a draft of the revisions and supporting calculations by May 15, 1992. This puts a severe time constraint on my efforts, and any data that you can provide would be appreciated. Please call me at (415) 961-5700, extension 3700, to confirm a date and time for our visit to Bay Area AQMD.

Sincerely,

Michael J. Chan
Project Engineer
Acurex Environmental Corporation

Acurex Environmental

CORPORATION

April 22, 1992

Mr. Clair Fancy
Buerau of Air Regulations
Department of Environmental Regulations
2600 Blairstone Road
Tallahassee, Florida 32399

Dear Mr. Fancy,

Acurex Environmental Corporation is currently engaged in an update of Chapters 1 and 3 in the document Compilation of Air Pollutant Emission Factors (AP-42's Volume I: Stationary Point and Area Sources) for the US EPA's Office of Air Quality Planning and Standards (OAQPS). I am responsible for sections 3 and 4 of Chapter 3, entitled "Gasoline and Diesel Industrial Engines" and "Stationary Large Bore Diesel and Dual Fuel Engines" respectively. An emission factor is the quantity (mass) of pollutants emitted divided by a unit of activity (e.g., g/hp-hr of NO_X). The emission factors are used in making estimates of areawide emissions, emission estimates for a specific facility, and evaluation of emissions in relation to ambient air quality.

The primary emissions of interest are uncontrolled criteria pollutant emissions that are already listed in AP-42 (I have enclosed a copy of the current sections 3.3 and 3.4 of AP-42). EPA's OAQPS would also like to include any available data on Speciated VOC's, Air Toxics, Greenhouse Gases, Fugitive Emissions, and Particulate Sizing (PM_{10}) in this current update. As I mentioned, the current emission factors in AP-42 are based on uncontrolled data, but I would like to include a new table of emission factors that would be based on controlled data.

The data needs to include as much detail as possible to enable the rating of the data quality by EPA guidelines (I also enclosed a copy of the page on data quality rating). Preferably, the data would include the actual source tests and data sheets.

Currently, the stationary internal combustion reciprocating engines are divided by fuel used (gasoline, diesel, and dual fuel), rated power (20 to 250 hp for gasoline engines and 45 to 600 hp for diesel engines) in section 3.3, and bore size (greater than 560 cubic inch displacement per cylinder for diesel and dual fuel engines) for in section 3.4. It has been suggested to me that the engines should be sorted by the rated power and fuel used to make AP-42 easier to use. Therefore, I would like to be able to sort the data by fuel and horsepower (I have a preference for data on engines greater than 600 hp due to the scarcity of the data). I am open to any suggestions on improving the sections 3.3 and 3.4 in AP-42.

555 Clyde Avenue, P.O. Box 7044, Mountain View, CA 94039 (415) 961-5700 FAX: (415) 964-6523/5145

I am also interested in the estimated existence or market share of stationary internal combustion reciprocating engines by rated power and fuel in the Unites States. I would appreciate any information on where I can find any sources for this type of information.

Because this phase of the update needs to be completed and published by June 1, 1992 for compliance with the Clean Air Act, I need to submit a draft of the revisions and supporting calculations by May 15, 1992. This puts a severe time constraint on my efforts, and any data that you can provide would be appreciated. If I can be of any assistance in collecting the information, please call me at (415) 961-5700, extension 3700.

Sincerely,

Michael J. Chan
Project Engineer
Acurex Environmental Corporation

3.3 Gasoline and Diesel Industrial Engines

3.3.1 General – This engine category covers a wide variety of industrial applications of both gasoline and diesel internal combustion power plants, such as fork lift trucks, mobile refrigeration units, generators, pumps, and portable well-drilling equipment. The rated power of these engines covers a rather substantial range–from less than 15 kW to 186 kW (20 to 250 hp) for gasoline engines and from 34 kW to 447 kW (45 to 600 hp) for diesel engines. Understandably, substantial differences in both annual usage (hours per year) and engine duty cycles also exist. It was necessary, therefore, to make reasonable assumptions concerning usage in order to formulate emission factors.[1]

3.3.2 Emissions – Once reasonable usage and duty cycles for this category were ascertained, emission values from each of the test engines [1] were aggregated (on the basis of nationwide engine population statistics) to arrive at the factors presented in Table 3.3-1. Because of their aggregate nature, data contained in this table must be applied to a population of industrial engines rather than to an individual power plant.

The best method for calculating emissions is on the basis of "brake specific" emission factors (g/kWh or lb/hphr). Emissions are calculated by taking the product of the brake specific emission factor, the usage in hours (that is, hours per year or hours per day), the power available (rated power), and the load factor (the power actually used divided by the power available).

Table 3.3-1. EMISSION FACTORS FOR GASOLINE AND DIESEL POWERED INDUSTRIAL EQUIPMENT
EMISSION FACTOR RATING: C

Pollutant[a]	Engine category[b]	
	Gasoline	Diesel
Carbon monoxide		
g/hr	5700.	197.
lb/hr	12.6	0.434
g/kWh	267.	4.06
g/hphr	199.	3.03
kg/10^3 liter	472.	12.2
lb/10^3 gal	3940.	102.
Exhaust hydrocarbons		
g/hr	191.	72.8
lb/hr	0.421	0.160
g/kWh	8.95	1.50
g/hphr	6.68	1.12
kg/10^3 liter	15.8	4.49
lb/10^3 gal	132.	37.5
Evaporative hydrocarbons		
g/hr	62.0	–
lb/hr	0.137	–
Crankcase hydrocarbons		
g/hr	38.3	–
lb/hr	0.084	–

Table 3.3-1 (continued). EMISSION FACTORS FOR GASOLINE AND DIESEL POWERED INDUSTRIAL EQUIPMENT
EMISSION FACTOR RATING: C

Pollutant[a]	Engine category[b]	
	Gasoline	Diesel
Nitrogen oxides		
g/hr	148.	910.
lb/hr	0.326	2.01
g/kWh	6.92	18.8
g/hphr	5.16	14.0
kg/10^3 liter	12.2	56.2
lb/10^3 gal	102.	469.
Aldehydes		
g/hr	6.33	13.7
lb/hr	0.014	0.030
g/kWh	0.30	0.28
g/hphr	0.22	0.21
kg/10^3 liter	0.522	0.84
lb/10^3 gal	4.36	7.04
Sulfur oxides		
g/hr	7.67	60.5
lb/hr	0.017	0.133
g/kWh	0.359	1.25
g/hphr	0.268	0.931
kg/10^3 liter	0.636	3.74
lb/10^3 gal	5.31	31.2
Particulate		
g/hr	9.33	65.0
lb/hr	0.021	0.143
g/kWh	0.439	1.34
g/hphr	0.327	1.00
kg/10^3 liter	0.775	4.01
lb/10^3 gal	6.47	33.5

[a]References 1 and 2.

[b]As discussed in the text, the engines used to determine the results in this table cover a wide range of uses and power. The listed values do not, however, necessarily apply to some very large stationary diesel engines.

References for Section 3.3

1. Hare, C. T. and K. J. Springer. Exhaust Emissions from Uncontrolled Vehicles and Related Equipment Using Internal Combustion Engines. Final Report. Part 5: Heavy-Duty Farm, Construction, and Industrial Engines. Southwest Research Institute. San Antonio, Texas. Prepared for Environmental Protection Agency, Research Triangle Park, N.C., under Contract No. EHS 70-108. October 1973. 105 p.

2. Hare, C. T. Letter to C. C. Masser of the Environmental Protection Agency concerning fuel-based emission rates for farm, construction, and industrial engines. San Antonio, Tex. January 14, 1974.

3.4 STATIONARY LARGE BORE DIESEL AND DUAL FUEL ENGINES

3.4.1 General

The primary domestic use of large bore diesel engines, i.e., those greater than 560 cubic inch displacement per cylinder (CID/CYL), is in oil and gas exploration and production. These engines, in groups of three to five, supply mechanical power to operate drilling (rotary table), mud pumping and hoisting equipment, and may also operate pumps or auxiliary power generators. Another frequent application of large bore diesels is electricity generation for both base and standby service. Smaller uses include irrigation, hoisting and nuclear power plant emergency cooling water pump operation.

Dual fuel engines were developed to obtain compression ignition performance and the economy of natural gas, using a minimum of 5 to 6 percent diesel fuel to ignite the natural gas. Dual fuel large bore engines (greater than 560 CID/CYL) have been used almost exclusively for prime electric power generation.

3.4.2 Emissions and Controls

The primary pollutant of concern from large bore diesel and dual fuel engines is NO_x, which readily forms in the high temperature, pressure and excess air environment found in these engines. Lesser amounts of carbon monoxide and hydrocarbons are also emitted. Sulfur dioxide emissions will usually be quite low because of the negligible sulfur content of diesel fuels and natural gas.

The major variables affecting NO_x emissions from diesel engines are injection timing, manifold air temperature, engine speed, engine load and ambient humidity. In general, NO_x emissions decrease with increasing humidity.

Because NO_x is the primary pollutant from diesel and dual fuel engines, control measures to date have been directed mainly at limiting NO_x emissions. The most effective NO_x control technique for diesel engines is fuel injection retard, achieving reductions (at eight degrees of retard) of up to 40 percent. Additional NO_x reductions are possible with combined retard and air/fuel ratio change. Both retarded fuel injection (8°) and air/fuel ratio change of five percent are also effective in reducing NO_x emissions from dual fuel engines, achieving nominal NO_x reductions of about 40 percent and maximum NO_x reductions of up to 70 percent.

Other NO_x control techniques exist but are not considered feasible because of excessive fuel penalties, capital cost, or maintenance or operational problems. These techniques include exhaust gas recirculation (EGR), combustion chamber modification, water injection and catalytic reduction.

TABLE 3.4-1. EMISSION FACTORS FOR STATIONARY LARGE BORE DIESEL AND DUAL FUEL ENGINES[a]

EMISSION FACTOR RATING: C

Engine type	Particulate[b]	Nitrogen oxides[c]	Carbon monoxide	VOC[d]		Sulfur dioxide[e]
				Methane	Nonmethane	
Diesel						
$lb/10^3$ hph	2.4	24	6.4	0.07	0.63	2.8
g/hph	1.1	11	2.9	0.03	0.29	1.3
g/kWh	1.5	15	3.9	0.04	0.4	1.7
$lb/10^3$ gal[f]	50	500	130	1	13	60
g/l	6	60	16	0.2	1.6	7.2
Dual fuel						
$lb/10^3$ hph	NA	18	5.9	4.7	1.5	0.70
g/hph	NA	8	2.7	2.1	0.7	0.32
g/kWh	NA	11	3.6	2.9	0.9	0.43

[a]Representative uncontrolled levels for each fuel, determined by weighting data from several manufacturers. Weighting based on % of total horsepower sold by each manufacturer during a five year period. NA = not available.

[b]Emission Factor Rating: E. Approximation based on test of a medium bore diesel. Emissions are minimum expected for engine operating at 50 - 100% full rated load. At 0% load, emissions would increase to 30 g/l. Reference 2.

[c]Measured as NO_2. Factors are for engines operated at rated load and speed.

[d]Nonmethane VOC is 90% of total VOC from diesel engines but only 25% of total VOC emissions from dual fuel engines. Individual chemical species within the nonmethane fraction are not identified. Molecular weight of nonmethane gas stream is assumed to be that of methane.

[e]Based on assumed sulfur content of 0.4 weight % for diesel fuel and 0.46 g/scm (0.20 gr/scf) for pipeline quality natural gas. Dual fuel SO_2 emissions based on 5% oil/95% gas mix. Emissions should be adjusted for other fuel ratios.

[f]These factors calculated from the above factors, assuming heating values of 40 MJ/l (145,000 Btu/gal) for oil and 41 MJ/scm (1100 Btu/scf) for natural gas, and an average fuel consumption of 9.9 MJ/kWh (7000 Btu/hph).

References for Section 3.4

1. Standards Support And Environmental Impact Statement, Volume I: Stationary Internal Combustion Engines, EPA-450/2-78-125a, U. S. Environmental Protection Agency, Research Triangle Park, NC, July 1979.

2. Telephone communication between William H. Lamason, Office Of Air Quality Planning And Standards, U. S. Environmental Protection Agency, Research Triangle Park, NC, and John H. Wasser, Office Of Research And Development, U. S. Environmental Protection Agency, Research Triangle Park, NC, July 15, 1983.

Data Quality Rating from the "Technical Procedures for Developing AP-42 Emission Factors and Preparing AP-42 Sections" by the Emission Inventory Branch (Technical Support Division) of U.S. EPA/OAQPS's Office of Air and Radiation (March 6, 1992) as follows:

A - When tests are performed by a sound methodology and are reported in enough detail for adequate validation. These tests are not necessarily EPA reference method tests, although such reference methods are preferred and certainly to be used as a guide.

B - When tests are performed by a generally sound methodology, but they lack enough detail for adequate validation.

C - When tests are based on an untested or new methodology or are lacking a significant amount of background data.

D - When tests are based on a generally unacceptable method but the method may provide an order-of-magnitude value for the source.

The author uses the following criteria to evaluate source test reports for sound methodology and adequate detail:

1. Source operation. The manner in which the source was operated is well documented in the report. The source was operating within typical parameters during the test.

2. Sampling procedures. If actual procedures deviated from standard methods, the deviations are well documented. Procedural alterations are often made in testing an uncommon type of source. When this occurs, an evaluation is made of how such alternative procedures could influence the test results.

3. Sampling and process data. Many variations can occur without warning during testing, sometimes without being noticed. Such variations can induce wide deviation in sampling results. If a large spread between test results cannot be explained by information contained in the test report, the data are suspect and are given a lower rating.

4. Analysis and calculations. The test reports contain original raw data sheets. The nomenclature and equations used are compared with those specified by EPA, to establish equivalency. The depth of review of the calculations is dictated by the reviewers' confidence in the ability and conscientiousness of the tester, which in turn is based on factors such as consistency of results and completeness of other areas of the test report.

cc: Bruce Higginbotham

Litton BIONETICS

5516 Nicholson Lane, Kensington, Maryland 20795 301 881-5600 • Telex 89-8369

December 10, 1980

RECEIVED

ACUREX

Mr. Roy Belletto
Acurex Corporation
485 Clyde Avenue
Mountain View, CA 94042

Dear Mr. Belletto:

Enclosed are five copies of the final reports for the compound sample #1452 submitted for evaluation in the Ames/Salmonella and the In Vivo Rodent Quantal Toxicity Assays. All studies were conducted and evaluated under EPA Level 1 guidelines. The final reports have been reviewed by the Litton Bionetics Quality Assurance Unit to ensure compliance with GLP regulations. These final reports supersede the two draft reports sent on December 3, 1980. There are no significant changes between the draft and final versions of the reports.

If you have any questions or comments concerning the reports, please feel free to contact me at (301)881-5600, extension 527. I hope we may be of service to you in the future.

Sincerely,

David J. Brusick

David J. Brusick, Ph.D.
Director
Department of Genetics
and Cell Biology

DJB/mg

Enclosures: 5394 - Ames
5394 - Rodent Quantal

BIOASSAY SUMMARY TABLE

Technical Directive or Project No. LBI Project No. 20933

Contract No. Acurex Subcontract RB59178A, Release No. 1

	Health Effects Tests				Ecological Effects Tests									
					Aquatic						Terrestrial			
					Fresh Water			Marine						
Sample Identification	AMES Salmonella*	RAM Cytotoxicity	CHO Cytotoxicity	Rodent Toxicity	Fish	Invertebrate	Algal	Fish	Invertebrate	Algal	Plant Stress Ethylene	Root Elongation	Insect Toxicity	Notes
1533 (CMEA	M		H											
Beloit No. 1														
XAD-2 Extract)														
1534 (CMEA	M		H/M											
Beloit No. 2														
XAD-2 Extract)														

ND = No Detectable Toxicity
L = Low Toxicity
M = Moderate Toxicity
H = High Toxicity
* Evaluation of Ames Salmonella test is based upon mutagenicity and not toxicity.

LBI-0468 R 11/80

DEFINITION OF TOXICITY CATEGORIES FOR HEALTH EFFECTS ASSAYS

Assay[a]	Activity Measured[b]	Sample Type[c]	MAD[d]	Units	Range of Concentration or Dosage: High	Moderate	Low	Not Detectable (ND)
Ames	MEC (mutagenesis)	S	5	mg/plate	<0.05	0.05-0.5	0.5-5	ND at >5
		AL,NAL	200	µl/plate	<2	2-20	20-200	ND at >200
		E	5000	L/plate	<50	50-500	500-5000	ND at >5000
RAM	EC_{50} (lethality)	S	1	mg/ml	<0.01	0.01-0.1	0.1-1	ND at >1
		AL	600	µl/ml	<6	6-60	60-600	ND at >600
		NAL	20	µl/ml	<0.2	0.2-2	2-20	ND at >20
		E	1000	L/ml	<10	10-100	100-1000	ND at >1000
CHO	EC_{50} (lethality)	S	1	mg/ml	<0.01	0.01-0.1	0.1-1	ND at >1
		AL	600	µl/ml	<6	6-60	60-600	ND at >600
		NAL	20	µl/ml	<0.2	0.2-2	2-20	ND at >20
		E	1000	L/ml	<10	10-100	100-1000	ND at >1000
WAT	LD_{50} (lethality and toxic signs)	S	5	gm/kg	<0.05	0.05-0.5	0.5-5	ND at >5
		AL,NAL	5	ml/kg	<0.05	0.05-0.5	0.5-5	ND at >5

[a]Standard test abbreviations are as follows:
- Ames: Ames *Salmonella*/microsome mutagenesis assay
- RAM: Rabbit alveolar macrophage cytotoxicity assay
- CHO: Rodent cell clonal toxicity assay
- WAT: Acute *in vivo* test in rodents (whole animal test)

[b]Standard abbreviations for measured endpoints are as follows:
- MEC: Minimum effective concentration
- EC_{50}: Calculated concentration expected to produce effect in 50 percent of population
- LD_{50}: Calculated dose expected to kill 50 percent of population

[c]S = Solid, AL = Aqueous liquid, NAL = Nonaqueous liquid, E = Extract and/or concentrate of unknown organic content (use equivalent volume of SASS train gas)

[d]MAD = Maximum applicable dose

TABLE

HEALTH EFFECTS CRITICAL DATA SUMMARY FORM[a]

Contract No. Acurex Subcontract RB59178A, Release 1 Technical Directive or Project No. LBI Project No. 20933 Site Sampled Beloit

Sample Identification	Ames Mutagenicity [MEC][b]	CHO Clonal Toxicity [EC_{50}][c]	RAM Cytotoxicity [EC50][c]				Rodent Toxicity	
			Viability	Viability Index	ATP	ATP/Per 10^6 Cells	LD_{50}[d]	Toxic Signs[e]
1533 (CMEA Beloit No. 1	13.0 µg	4.29 µg/ml						
XAD-2 Extract)								
1534 (CMEA Beloit No. 2	302.5 µg	13.3 µg/ml						
XAD-2 Extract)								

[a]The assays, observed parameters and evaluation criteria are presented in IERL-RTP Procedures Manual; Level 1 Environmental Assessment Biological Tests, [EPA Contract No. 68-02-2681, Litton Bionetics, Inc., Kensington, Md., September 1980, in press.]

[b]MEC: Minimum Effective Concentration - Lowest concentration for any tester strain giving a mutagenic response.

[c]EC_{50}: Effective concentration that reduces the observed parameter to 50 percent of the appropriate negative control.

[d]LD_{50}: The dose lethal to 50 percent of treated animals.

[e]Toxic signs are identified in a numbered list in the Level 1 manual. Only the number is reported here.

LBI-0798 1/81

	DATA RATING	DIESEL ENGINES g/kW-hr	DIESEL ENGINES ng/J	DATA RATING	DUAL FUEL ENGINES g/kW-hr	DUAL FUEL ENGINES ng/J	
Criteria Non-Organic Gases							
NOx	C	14	1322	D	12.3	1331	
CO	C	3.2	349	D	3.1	340	
SOx (1 engine)	D	0.55	55	E	0.43	42	Bse on Ass
CO2 (1 engine)	D		82569				
Organic Compound Emissions							
Total HC (as CH4)	C	0.43	38	D	3.2	352	
Methane (1 engine)	D	0.04	4	E	2.4	240	Bse on Ass
Nonmethane (1 engine)	D	0.44	45	E	0.8	80	Bse on Ass
Benzene (1 engine)	D		3.34E-01				
Toluene (1 engine)	D		1.21E-01				
Xylenes (1 engine)	D		8.30E-02				
Propylene (1 engine)	D		1.20E+00				
Formaldehyde (1 engine)	D		3.39E-02				
Acetaldehyde (1 engine)	D		1.08E-02				
Acrolein (1 engine)	D		3.39E-03				
Polycyclic Aromatic Hydrocarbons (PAH) (Based on 1 engine)							
Naphthalene	D		5.59E-02				
Acenaphthylene	D		3.97E-03				
Acenaphthene	D		2.01E-03				
Fluorene	D		5.50E-03				
Phenanthrene	D		1.75E-02				
Anthracene	D		5.29E-04				
Fluoranthene	D		1.73E-03				
Pyrene	D		1.60E-03				
Benz(a)anthracene	D		2.67E-04				
Chrysene	D		6.58E-04				
Benzo(b)fluoranthene	D		4.77E-04				
Benzo(k)fluoranthene	D		<9.37E-05				
Benzo(a)pyrene	D		<1.10E-04				
Indeno(1,2,3-cd)pyrene	D		<1.78E-04				
Dibenz(a,h)anthracene	D		<1.49E-04				
Benzo(g,h,l)perylene	D		<2.39E-04				
Total (PAH)	D		9.09E-02				
Particulate Size Distribution (Based on 1 engine)							
<1 um	D	0.2038	20.56				
1-3 um	D	0.0005	0.05				
3-10 um	D	0.0072	0.73				
>10 um	D	0.0528	5.33				
Total	D	0.2644	26.67				
Patticulate Emissions (Method 5) (Based on 1 engine)							
Solids	D	0.2925	29.49				
Condensables	D	0.0329	3.31				
Total	D	0.3253	32.81				

	DATA RATING	DIESEL ENGINES g/hp-hr	DIESEL ENGINES lb/Mgal	DIESEL ENGINES lb/MMBtu	DATA RATING	DUAL FUEL ENGINES g/hp-hr	DUAL FUEL ENGINES lb/Mgal	DUAL FUEL ENGINES lb/MMBtu	
Criteria Non-Organic Gases									
NOx	C	11	421	3.1	D	9.2	424	3.1	
CO	C	2.4	111	0.81	D	2.3	108	0.79	
SOx (1 engine)	D	0.41	17	0.13	E	0.32	14	0.10	Bse on Ass
CO2 (1 engine)	D		26559	192					
Organic Compound Emissions									
Total HC (as CH4)	C	0.32	12.2	0.09	D	2.4	112	0.8	
Methane (1 engine)	D	0.03	1	0.01	E	1.8	79	0.6	Bse on Ass
Nonmethane (1 engine)	D	0.33	14	0.10	E	0.6	26	0.2	Bse on Ass
Benzene (1 engine)	D		0.1073	7.76E-04					
Toluene (1 engine)	D		0.0388	2.81E-04					
Xylenes (1 engine)	D		0.0268	1.93E-04					
Propylene (1 engine)	D		0.3863	2.79E-03					
Formaldehyde (1 engine)	D		0.0109	7.89E-05					
Acetaldehyde (1 engine)	D		0.0035	2.52E-05					
Acrolein (1 engine)	D		0.0011	7.88E-06					
Polycyclic Aromatic Hydrocarbons (PAH) (Based on 1 engine)									
Naphthalene	D		0.0180	1.30E-04					
Acenaphthylene	D		0.0013	9.23E-06					
Acenaphthene	D		0.0006	4.68E-06					
Fluorene	D		0.0018	1.28E-05					
Phenanthrene	D		0.0056	4.08E-05					
Anthracene	D		0.0002	1.23E-06					
Fluoranthene	D		0.0006	4.03E-06					
Pyrene	D		0.0005	3.71E-06					
Benz(a)anthracene	D		0.0001	6.22E-07					
Chrysene	D		0.0002	1.53E-06					
Benzo(b)fluoranthene	D		0.0002	1.11E-06					
Benzo(k)fluoranthene	D		< 0.00003	<2.18E-07					
Benzo(a)pyrene	D		< 0.00004	<2.57E-07					
Indeno(1,2,3-cd)pyrene	D		< 0.0001	<4.14E-07					
Dibenz(a,h)anthracene	D		< 0.00005	<3.46E-07					
Benzo(g,h,l)perylene	D		< 0.0001	<5.56E-07					
Total (PAH)	D		0.0294	2.12E-04					
Particulate Size Distribution (Based on 1 engine)									
<1 um	D	0.1520	6.4302	0.0478					
1-3 um	D	0.0004	0.0169	0.0001					
3-10 um	D	0.0054	0.2284	0.0017					
>10 um	D	0.0394	1.6668	0.0124					
Total	D	0.1972	8.3424	0.0620					
Patticulate Emissions (Method 5) (Based on 1 engine)									
Solids	D	0.2181	9.2265	0.0686					
Condensables	D	0.0245	1.0365	0.0077					
Total	D	0.2426	10.2630	0.0763					

Trace Element Emissions
(Based on 1 engine)
05/20/92

Section 3.4

BASED ON: BSFC = 7,009 Btu/hph
HHV = 134,497 Btu/gal
Engine= 2,100 hp

	Lube Oil g/hp-hr	Lube Oil lb/Mgal	Lube Oil lb/MMBtu	Diesel Fuel g/hp-hr	Diesel Fuel lb/Mgal	Diesel Fuel lb/MMBtu	Exhaust g/hp-hr	Exhaust lb/Mgal	Exhaust lb/MMBtu	RAW DATA Lube Oil ug/s	RAW DATA Fuel ug/s	RAW DATA Exhaust ug/s	% Out	0-50% Out	>50-150% Out
Aluminum	4.29E-07	1.81E-05	1.35E-07	>3.60E-03	>1.52E-01	>1.13E-03	>3.94E-03	>1.67E-01	>1.24E-03	0.25	> 2100	> 2300	110%		110% Aluminum
Antimony	1.20E-08	5.08E-07	3.77E-09	------	------	------	9.94E-07	4.21E-05	3.13E-07	0.007		0.58	8286%		
Arsenic	6.00E-07	2.54E-05	1.89E-07	------	------	------	5.49E-07	2.32E-05	1.73E-07	0.35		0.32	91%		91% Arsenic
Barium	3.09E-05	1.31E-03	9.71E-06	1.34E-04	5.66E-03	4.21E-05	4.97E-06	2.10E-04	1.56E-06	18	78	2.9	3%	3% Barium	
Beryllium	<6.86E-09	<2.90E-07	<2.16E-09	------	------	------	<5.49E-08	<2.32E-06	<1.73E-08	< 0.004		< 0.032	800%		
Bismuth	------	------	------	------	------	------	<5.49E-08	<2.32E-06	<1.73E-08			< 0.032			
Boron	<6.86E-09	<2.90E-07	<2.16E-09	3.43E-06	1.45E-04	1.08E-06	6.17E-05	2.61E-03	1.94E-05	< 0.004	2	36	1796%		
Bromine	4.29E-07	1.81E-05	1.35E-07	6.69E-05	2.83E-03	2.10E-05	2.57E-05	1.09E-03	8.09E-06	0.25	39	15	38%	38% Bromine	
Cadmium	4.29E-08	1.81E-06	1.35E-08	------	------	------	<1.05E-05	<4.42E-04	<3.29E-06	0.025		< 6.1	24400%		
Calcium	>6.00E-05	>2.54E-03	>1.89E-05	8.57E-03	3.63E-01	2.70E-03	3.94E-03	1.67E-01	1.24E-03	> 35	5000	2300	46%	46% Calcium	
Cerium	------	------	------	------	------	------	4.97E-07	2.10E-05	1.56E-07			0.29			
Cesium	6.86E-09	2.90E-07	2.16E-09	------	------	------	<5.49E-07	<2.32E-05	<1.73E-07	0.004		< 0.32	8000%		
Chlorine	3.26E-05	1.38E-03	1.02E-05	1.17E-04	4.93E-03	3.67E-05	4.97E-05	2.10E-03	1.56E-05	19	68	29	33%	33% Chlorine	
Chromium	4.11E-06	1.74E-04	1.29E-06	8.40E-06	3.55E-04	2.64E-06	1.49E-05	6.31E-04	4.69E-06	2.4	4.9	8.7	119%		119% Chromium
Cobalt	4.29E-07	1.81E-05	1.35E-07	1.34E-05	5.66E-04	4.21E-06	1.47E-06	6.24E-05	4.64E-07	0.25	7.8	0.86	11%	11% Cobalt	
Copper	3.09E-06	1.31E-04	9.71E-07	1.01E-04	4.28E-03	3.18E-05	4.63E-04	1.96E-02	1.46E-04	1.8	59	270	444%		
Fluorine	1.22E-07	5.15E-06	3.83E-08	3.43E-05	1.45E-03	1.08E-05	2.57E-05	1.09E-03	8.09E-06	0.071	20	15	75%		75% Fluorine
Gallium	3.09E-08	1.31E-06	9.71E-09	------	------	------	2.40E-06	1.02E-04	7.55E-07	0.018		1.4	7778%		
Germanium	------	------	------	------	------	------	<5.49E-07	<2.32E-05	<1.73E-07			< 0.32			
Iodine	------	------	------	<4.97E-06	<2.10E-04	<1.56E-06	1.10E-07	4.64E-06	3.45E-08		< 2.9	0.064	2%	2% Iodine	
Iron	5.14E-05	2.18E-03	1.62E-05	1.68E-03	7.11E-02	5.28E-04	1.49E-03	6.31E-02	4.69E-04	30	980	870	86%		86% Iron
Lanthanum	1.89E-08	7.98E-07	5.93E-09	------	------	------	1.47E-06	6.24E-05	4.64E-07	0.011		0.86	7818%		
Lead	6.00E-07	2.54E-05	1.89E-07	3.43E-05	1.45E-03	1.08E-05	5.14E-06	2.18E-04	1.62E-06	0.35	20	3	15%	15% Lead	
Lithium	4.29E-08	1.81E-06	1.35E-08	1.01E-05	4.28E-04	3.18E-06	4.46E-07	1.89E-05	1.40E-07	0.025	5.9	0.26	4%	4% Lithium	
Magnesium	1.89E-06	7.98E-05	5.93E-07	3.43E-04	1.45E-02	1.08E-04	1.59E-04	6.74E-03	5.01E-05	1.1	200	93	46%	46% Magnesium	
Manganese	3.09E-07	1.31E-05	9.71E-08	3.43E-05	1.45E-03	1.08E-05	3.94E-05	1.67E-03	1.24E-05	0.18	20	23	114%		114% Manganese
Mercury	------	------	------	------	------	------	<4.97E-04	<2.10E-02	<1.56E-04			< 290			
Molybdenum	2.40E-07	1.02E-05	7.55E-08	3.43E-04	1.45E-02	1.08E-04	5.14E-06	2.18E-04	1.62E-06	0.14	200	3	1%	1% Molybdenum	
Neodynium	------	------	------	------	------	------	1.47E-06	6.24E-05	4.64E-07			0.86			
Nickel	1.22E-06	5.15E-05	3.83E-07	1.17E-04	4.93E-03	3.67E-05	8.40E-05	3.55E-03	2.64E-05	0.71	68	49	71%		71% Nickel
Niobium	------	------	------	------	------	------	<4.97E-07	<2.10E-05	<1.56E-07			< 0.29			
Phosphorus	3.60E-06	1.52E-04	1.13E-06	1.17E-03	4.93E-02	3.67E-04	>4.46E-03	>1.89E-01	>1.40E-03	2.1	680	> 2600	381%		
Potassium	>6.00E-05	>2.54E-03	>1.89E-05	7.37E-03	3.12E-01	2.32E-03	>8.06E-03	>3.41E-01	>2.53E-03	> 35	4300	> 4700	108%		108% Potassium
Rubidium	2.40E-08	1.02E-06	7.55E-09	------	------	------	4.46E-06	1.89E-04	1.40E-06	0.014		2.6	18571%		
Samarium	------	------	------	------	------	------	5.49E-08	2.32E-06	1.73E-08			0.032			
Scandium	1.20E-08	5.08E-07	3.77E-09	<3.43E-06	<1.45E-04	<1.08E-06	4.97E-05	2.10E-03	1.56E-05	0.007	< 2	29	1445%		
Selenium	1.89E-07	7.98E-06	5.93E-08	------	------	------	1.47E-04	6.24E-03	4.64E-05	0.11		86	78182%		
Silicon	5.83E-05	2.47E-03	1.83E-05	2.57E-03	1.09E-01	8.09E-04	2.06E-03	8.70E-02	6.47E-04	34	1500	1200	78%		78% Silicon
Silver	6.86E-09	2.90E-07	2.16E-09	------	------	------	6.34E-05	2.68E-03	2.00E-05	0.004		37	925000%		
Sodium	>6.00E-05	>2.54E-03	>1.89E-05	1.68E-04	7.11E-03	5.28E-05	>4.63E-03	>1.96E-01	>1.46E-03	> 35	98	> 2700	2030%		
Strontium	1.39E-05	5.87E-04	4.37E-06	1.68E-05	7.11E-04	5.28E-06	9.94E-06	4.21E-04	3.13E-06	8.1	9.8	5.8	32%	32% Strontium	
Sulfur	>5.83E-03	>2.47E-01	>1.83E-03	3.26E-01	1.38E+01	1.02E-01	>7.03E-03	>2.97E-01	>2.21E-03	> 3400	190000	> 4100	2%	2% Sulfur	
Tellerium	------	------	------	------	------	------	2.74E-07	1.16E-05	8.63E-08			0.16			
Tin	1.22E-07	5.15E-06	3.83E-08	------	------	------	3.43E-05	1.45E-03	1.08E-05	0.071		20	28169%		
Titanium	4.29E-06	1.81E-04	1.35E-06	3.43E-04	1.45E-02	1.08E-04	1.53E-04	6.45E-03	4.80E-05	2.5	200	89	44%	44% Titanium	
Tungsten	------	------	------	<1.68E-05	<7.11E-04	<5.28E-06	------	------	------		< 9.8		0%	0%	
Vanadium	2.40E-08	1.02E-06	7.55E-09	6.69E-06	2.83E-04	2.10E-06	4.97E-07	2.10E-05	1.56E-07	0.014	3.9	0.29	7%	7% Vanadium	
Yttrium	------	------	------	------	------	------	<4.97E-07	<2.10E-05	<1.56E-07			< 0.29			
Zinc	1.08E-05	4.57E-04	3.40E-06	1.51E-04	6.38E-03	4.75E-05	4.80E-04	2.03E-02	1.51E-04	6.3	88	280	297%		
Zirconium	------	------	------	1.51E-05	6.38E-04	4.75E-06	6.17E-06	2.61E-04	1.94E-06		8.8	3.6	41%	41% Zirconium	

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE	Data Qual.	Fuel	Rating Hp	wt % S (Fuel)	%O2	Exit dscfm	F factor dscf/MMBtu	Heat Input MMBtu/hr	BSFC Btu/hph	HHV Btu/lb	HHV Btu/gal	UNITS	Criteria Non-Organic Gaseous Emissions NOx	CO	SOx	CO2
SSEIS, Vol. 1 (3)	B	Diesel	610						6,930	19,300	137,030	g/hph	8.70	8.50		
Engine 24												lb/Mgal	379	371		
Section 3.4												lb/MMBtu	2.77	2.70		
SSEIS, Vol. 1 (3)	B	Diesel	711						7,040	19,300	137,030	g/hph	4.80	3.90		
Engine 62												lb/Mgal	206	167		
Section 3.4												lb/MMBtu	1.50	1.22		
AB2588 for WSPA (2)	B	Diesel	850	0.03	10.2		9,157			19,479	138,300	ug/m3				
Drilling Rig		At 100% load?										ppm		308		94,000
Section 3.4		hp & hr invalid										ppb				
												lb/hr				
												g/hph				
												lb/Mgal		55		26,559
												lb/MMBtu		0.40		192.04
SSEIS, Vol. 1 (3)	B	Diesel	1,100							19,300	137,030	g/hph	17.07	2.20		
Engine 43												lb/Mgal	ERR	ERR		
Section 3.4												lb/MMBtu	ERR	ERR		
SSEIS, Vol. 1 (3)	B	Diesel	1,300						6,668	19,300	137,030	g/hph	8.80	0.50		
Engine 56												lb/Mgal	399	23		
Section 3.4												lb/MMBtu	2.91	0.17		
SSEIS, Vol. 1 (3)	B	Diesel	1,336						6,962	19,300	137,030	g/hph	7.30	1.80		
Engine 55												lb/Mgal	317	78		
Section 3.4												lb/MMBtu	2.31	0.57		
SSEIS, Vol. 1 (3)	B	Diesel	1,650							19,300	137,030	g/hph	12.88	0.93		
Engine 41												lb/Mgal	ERR	ERR		
Section 3.4												lb/MMBtu	ERR	ERR		
SSEIS, Vol. 1 (3)	B	Diesel	1,650							19,300	137,030	g/hph	14.74	4.14		
Engine 42												lb/Mgal	ERR	ERR		
Section 3.4												lb/MMBtu	ERR	ERR		
ACUREX TR-81-81/EE	A	Diesel	2,100	0.19	13.7		9,220		7,009	18,943	134,497	g/hph	11.0	0.96	0.41	
(4)												lb/Mgal	465	41	17	
Section 3.4												lb/MMBtu	3.46	0.30	0.13	
SSEIS, Vol. 1 (3)	B	Diesel	2,200						7,565	19,300	137,030	g/hph	16.81	3.83		
Engine 17												lb/Mgal	671	153		
Section 3.4												lb/MMBtu	4.90	1.12		
SSEIS, Vol. 1 (3)	B	Diesel	2,410						6,366	19,300	137,030	g/hph	11.24	3.02		
Engine 15												lb/Mgal	533	143		
Section 3.4												lb/MMBtu	3.89	1.05		
SSEIS, Vol. 1 (3)	B	Diesel	2,475							19,300	137,030	g/hph	12.61	1.19		
Engine 3												lb/Mgal	ERR	ERR		
Section 3.4												lb/MMBtu	ERR	ERR		

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE	Data Qual.	Fuel	Rating Hp	wt % S (Fuel)	%O2	Exit dscfm	F factor dscf/MMBtu	Heat Input MMBtu/hr	BSFC Btu/hph	HHV Btu/lb	HHV Btu/gal	UNITS	Criteria Non-Organic Gaseous Emissions NOx	CO	SOx	CO2
SSEIS, Vol. 1 (3)	B	Diesel	2,675						6,943	19,300	137,030	g/hph	8.40	1.30		
Engine 57												lb/Mgal	365	57		
Section 3.4												lb/MMBtu	2.67	0.41		
SSEIS, Vol. 1 (3)	B	Diesel	2,800						7,328	19,300	137,030	g/hph	4.70	1.80		
Engine 58												lb/Mgal	194	74		
Section 3.4												lb/MMBtu	1.41	0.54		
SSEIS, Vol. 1 (3)	B	Diesel	3,300						6,744	19,300	137,030	g/hph	14.52	1.14		
Engine 18												lb/Mgal	650	51		
Section 3.4												lb/MMBtu	4.75	0.37		
SSEIS, Vol. 1 (3)	B	Diesel	3,631						6,302	19,300	137,030	g/hph	9.40			
Engine 52												lb/Mgal	451			
Section 3.4												lb/MMBtu	3.29			
SSEIS, Vol. 1 (3)	B	Diesel	3,900							19,300	137,030	g/hph	11.87	0.73		
Engine 19												lb/Mgal	ERR	ERR		
Section 3.4												lb/MMBtu	ERR	ERR		
SSEIS, Vol. 1 (3)	B	Diesel	3,900						6,888	19,300	137,030	g/hph	7.90	1.30		
Engine 59												lb/Mgal	346	57		
Section 3.4												lb/MMBtu	2.53	0.42		
SSEIS, Vol. 1 (3)	B	Diesel	4,300						6,677	19,300	137,030	g/hph	10.99	3.85		
Engine 5												lb/Mgal	497	174		
Section 3.4												lb/MMBtu	3.63	1.27		
SSEIS, Vol. 1 (3)	B	Diesel	4,880						6,650	19,300	137,030	g/hph	8.50			
Engine 51												lb/Mgal	386			
Section 3.4												lb/MMBtu	2.82			
SSEIS, Vol. 1 (3)	B	Diesel	7,313						6,485	19,300	137,030	g/hph	9.70			
Engine 47												lb/Mgal	452			
Section 3.4												lb/MMBtu	3.30			
THE DATA BELOW IS NOT USED DUE TO THE AMBIGUITY OF THE ENGINE SIZE																
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						6,643	19,300	137,030	g/hph	10.80	1.71		
Engine 8												lb/Mgal	491	78		
Section 3.4												lb/MMBtu	3.58	0.57		
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						6,643	19,300	137,030	g/hph	11.40			
Engine 9												lb/Mgal	518			
Section 3.4												lb/MMBtu	3.78			
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						7,844	19,300	137,030	g/hph	18.80	0.63		
Engine 10												lb/Mgal	724	24		
Section 3.4												lb/MMBtu	5.28	0.18		
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						6,951	19,300	137,030	g/hph	16.30	0.53		
Engine 11												lb/Mgal	708	23		
Section 3.4												lb/MMBtu	5.17	0.17		

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE	Data Qual.	Fuel	Rating Hp	wt % S (Fuel)	%O2	Exit dscfm	F factor dscf/MMBtu	Heat Input MMBtu/hr	BSFC Btu/hph	HHV Btu/lb	HHV Btu/gal	UNITS	Criteria Non-Organic Gaseous Emissions NOx	CO	SOx	CO2
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						6,679	19,300	137,030	g/hph	10.70	0.85		
Engine 12												lb/Mgal	484	38		
Section 3.4												lb/MMBtu	3.53	0.28		
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						7,147	19,300	137,030	g/hph	8.60	2.10		
Engine 26												lb/Mgal	364	89		
Section 3.4												lb/MMBtu	2.65	0.65		
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						6,667	19,300	137,030	g/hph	7.40	0.80		
Engine 27												lb/Mgal	335	36		
Section 3.4												lb/MMBtu	2.45	0.26		
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						7,325	19,300	137,030	g/hph	10.00	4.30		
Engine 35												lb/Mgal	412	177		
Section 3.4												lb/MMBtu	3.01	1.29		
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						6,778	19,300	137,030	g/hph	8.20	1.00		
Engine 36												lb/Mgal	365	45		
Section 3.4												lb/MMBtu	2.67	0.33		
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						6,870	19,300	137,030	g/hph	8.30	1.60		
Engine 60												lb/Mgal	365	70		
Section 3.4												lb/MMBtu	2.66	0.51		
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						6,618	19,300	137,030	g/hph	15.50			
Engine 68												lb/Mgal	708			
Section 3.4												lb/MMBtu	5.16			
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						6,508	19,300	137,030	g/hph	12.60	0.71		
Engine 72												lb/Mgal	585	33		
Section 3.4												lb/MMBtu	4.27	0.24		
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						6,809	19,300	137,030	g/hph	9.30	0.57		
Engine 73												lb/Mgal	413	25		
Section 3.4												lb/MMBtu	3.01	0.18		
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						6,741	19,300	137,030	g/hph	8.50	0.65		
Engine 74												lb/Mgal	381	29		
Section 3.4												lb/MMBtu	2.78	0.21		
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						7,035	19,300	137,030	g/hph	6.20	3.90		
Engine 75												lb/Mgal	266	167		
Section 3.4												lb/MMBtu	1.94	1.22		
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL						6,504	19,300	137,030	g/hph	11.40	0.91		
Engine 77												lb/Mgal	530	42		
Section 3.4												lb/MMBtu	3.86	0.31		

(1) EMISSIONS OF AIR TOXIC SPECIES: TEST CONDUCTED UNDER AB2588 FOR THE WESTERN STATES PETROLEUM ASSOCIATION BY CARNOT (CR 72600-2061) IN MAY 1990
USING CARB TEST METHODS 100, 410A, 429, & 430

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE	Data Qual.	Fuel	Rating Hp	wt % S (Fuel)	%O2	Exit dscfm	F factor dscf/MMBtu	Heat Input MMBtu/hr	BSFC Btu/hph	HHV Btu/lb	HHV Btu/gal	UNITS	Criteria Non-Organic Gaseous Emissions NOx	CO	SOx	CO2

(2) POOLED SOURCE EMISSION TEST REPORT: OIL AND GAS PRODUCTION COMBUSTION SOURCES, FRESNO AND VENTURA COUNTIES, CALIFORNIA BY ENSR CONSULTING AND ENGINEERING (ENSR #7230-007-700) IN DECEMBER 1990
USING CARB TEST METHODS 100, 410A, MODIFIED 429, 430, AND EPA TEST METHOD 18

(3) STANDARDS SUPPORT AND ENVIRONMENTAL IMPACT STATEMENT, VOLUME I: STATIONARY INTERNAL COMBUSTION ENGINES, EPA-450/2-78-125a, U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NC, JULY 1979
USED MODIFIED REFERENCE METHOD 20

(4) ENVIRONMENTAL ASSESSMENT OF NOx CONTROL ON A COMPRESSION IGNITION LARGE BORE RECIPROCATING INTERNAL COMBUSTION ENGINE, VOLUME I: TECHNICAL RESULTS, ACUREX REPORT TR-81-81/EE, APRIL 1984
USED DIESEL ENGINE MANUFACTURERS ASSOCIATION EXHAUST EMISSION MEASUREMENT PROCEDURES

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE	Data Qual.	Fuel	Rating Hp	wt % S (Fuel)	%O2	Exit dscfm	F factor dscf/MMBtu	Heat Input MMBtu/hr	BSFC Btu/hph	HHV Btu/lb	HHV Btu/gal	UNITS	Criteria Non-Organic Gaseous Emissions NOx	CO	SOx	CO2
SSEIS, Vol. 1 (3)	B	Dual F	711						6,570	19,300	137,030	g/hph	7.30	2.00		
Engine 61												lb/Mgal	336	92		
Section 3.4												lb/MMBtu	2.45	0.67		
SSEIS, Vol. 1 (3)	B	Dual F	2,410						6,464	19,300	137,030	g/hph	7.79	3.69		
Engine 16												lb/Mgal	364	172		
Section 3.4												lb/MMBtu	2.66	1.26		
SSEIS, Vol. 1 (3)	B	Dual F	4,300						6,340	19,300	137,030	g/hph	8.96	4.50		
Engine 6												lb/Mgal	427	214		
Section 3.4												lb/MMBtu	3.12	1.56		
SSEIS, Vol. 1 (3)	B	Dual F	8,658						6,225	19,300	137,030	g/hph	4.40			
Engine 50												lb/Mgal	214			
Section 3.4												lb/MMBtu	1.56			
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL						6,400	19,300	137,030	g/hph	12.70	1.35		
Engine 7												lb/Mgal	599	64		
Section 3.4												lb/MMBtu	4.37	0.47		
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL						7,040	19,300	137,030	g/hph	8.80	1.71		
Engine 13												lb/Mgal	378	73		
Section 3.4												lb/MMBtu	2.76	0.54		
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL						7,170	19,300	137,030	g/hph	14.93	1.25		
Engine 14												lb/Mgal	629	53		
Section 3.4												lb/MMBtu	4.59	0.38		
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL						6,208	19,300	137,030	g/hph	10.60	2.89		
Engine 76												lb/Mgal	516	141		
Section 3.4												lb/MMBtu	3.76	1.03		
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL						6,297	19,300	137,030	g/hph	7.40	1.20		
Engine 78												lb/Mgal	355	58		
Section 3.4												lb/MMBtu	2.59	0.42		

(3) STANDARDS SUPPORT AND ENVIRONMENTAL IMPACT STATEMENT, VOLUME I: STATIONARY INTERNAL COMBUSTION ENGINES, EPA-450/2-78-125a, U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NC, JULY 1979
USED MODIFIED REFERENCE METHOD 20

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Organic Compound Emissions Methane	Nonmethane	Total HC (as CH4)	Benzene	Toluene	Xylenes	Propylene	1,3 Butadiene	Formaldehyde	Acetaldehyde	Acrolein
SSEIS, Vol. 1 (3)	B	Diesel	610	g/hph			0.25								
Engine 24				lb/Mgal			11								
Section 3.4				lb/MMBtu			0.08								
SSEIS, Vol. 1 (3)	B	Diesel	711	g/hph			0.18								
Engine 62				lb/Mgal			8								
Section 3.4				lb/MMBtu			0.06								
AB2588 for WSPA (2)	B	Diesel	850	ug/m3											
Drilling Rig		At 100% load?		ppm			34.5	0.213	0.064	0.040	1.433		0.057	0.012	0.003
Section 3.4		hp & hr invalid		ppb											
				lb/hr											
				g/hph											
				lb/Mgal			3.25	0.1073	0.0388	0.0268	0.3863		0.0109	0.0035	0.0011
				lb/MMBtu			2.35E-02	7.76E-04	2.81E-04	1.93E-04	2.79E-03		7.89E-05	2.52E-05	7.88E-06
SSEIS, Vol. 1 (3)	B	Diesel	1,100	g/hph			0.37								
Engine 43				lb/Mgal			ERR								
Section 3.4				lb/MMBtu			ERR								
SSEIS, Vol. 1 (3)	B	Diesel	1,300	g/hph			0.10								
Engine 56				lb/Mgal			5								
Section 3.4				lb/MMBtu			0.03								
SSEIS, Vol. 1 (3)	B	Diesel	1,336	g/hph			0.30								
Engine 55				lb/Mgal			13								
Section 3.4				lb/MMBtu			0.09								
SSEIS, Vol. 1 (3)	B	Diesel	1,650	g/hph			0.42								
Engine 41				lb/Mgal			ERR								
Section 3.4				lb/MMBtu			ERR								
SSEIS, Vol. 1 (3)	B	Diesel	1,650	g/hph			0.49								
Engine 42				lb/Mgal			ERR								
Section 3.4				lb/MMBtu			ERR								
ACUREX TR-81-81/EE	A	Diesel	2,100	g/hph	0.03	0.33	0.36								
(4)				lb/Mgal	1	14	15								
Section 3.4				lb/MMBtu	0.01	0.10	0.11								
SSEIS, Vol. 1 (3)	B	Diesel	2,200	g/hph			0.42								
Engine 17				lb/Mgal			17								
Section 3.4				lb/MMBtu			0.12								
SSEIS, Vol. 1 (3)	B	Diesel	2,410	g/hph			0.46								
Engine 15				lb/Mgal			22								
Section 3.4				lb/MMBtu			0.16								
SSEIS, Vol. 1 (3)	B	Diesel	2,475	g/hph			0.38								
Engine 3				lb/Mgal			ERR								
Section 3.4				lb/MMBtu			ERR								

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Organic Compound Emissions Methane	Nonmethane	Total HC (as CH4)	Benzene	Toluene	Xylenes	Propylene	1,3 Butadiene	Formaldehyde	Acetaldehyde	Acrolein
SSEIS, Vol. 1	(3) B	Diesel	2,675	g/hph			0.30								
Engine 57				lb/Mgal			13								
Section 3.4				lb/MMBtu			0.10								
SSEIS, Vol. 1	(3) B	Diesel	2,800	g/hph			0.20								
Engine 58				lb/Mgal			8								
Section 3.4				lb/MMBtu			0.06								
SSEIS, Vol. 1	(3) B	Diesel	3,300	g/hph			0.42								
Engine 18				lb/Mgal			19								
Section 3.4				lb/MMBtu			0.14								
SSEIS, Vol. 1	(3) B	Diesel	3,631	g/hph			0.27								
Engine 52				lb/Mgal			13								
Section 3.4				lb/MMBtu			0.09								
SSEIS, Vol. 1	(3) B	Diesel	3,900	g/hph			0.37								
Engine 19				lb/Mgal			ERR								
Section 3.4				lb/MMBtu			ERR								
SSEIS, Vol. 1	(3) B	Diesel	3,900	g/hph			0.50								
Engine 59				lb/Mgal			22								
Section 3.4				lb/MMBtu			0.16								
SSEIS, Vol. 1	(3) B	Diesel	4,300	g/hph			0.13								
Engine 5				lb/Mgal			6								
Section 3.4				lb/MMBtu			0.04								
SSEIS, Vol. 1	(3) B	Diesel	4,880	g/hph			0.31								
Engine 51				lb/Mgal			14								
Section 3.4				lb/MMBtu			0.10								
SSEIS, Vol. 1	(3) B	Diesel	7,313	g/hph			0.17								
Engine 47				lb/Mgal			8								
Section 3.4				lb/MMBtu			0.06								
THE DATA BELOW IS NOT USED DUE TO THE AMBIGUITY OF THE ENGINE SIZE															
SSEIS, Vol. 1	(3) C	Diesel	>350 CID/CYL	g/hph			1.00								
Engine 8				lb/Mgal			45								
Section 3.4				lb/MMBtu			0.33								
SSEIS, Vol. 1	(3) C	Diesel	>350 CID/CYL	g/hph			0.44								
Engine 9				lb/Mgal			20								
Section 3.4				lb/MMBtu			0.15								
SSEIS, Vol. 1	(3) C	Diesel	>350 CID/CYL	g/hph			0.55								
Engine 10				lb/Mgal			21								
Section 3.4				lb/MMBtu			0.15								
SSEIS, Vol. 1	(3) C	Diesel	>350 CID/CYL	g/hph			0.18								
Engine 11				lb/Mgal			8								
Section 3.4				lb/MMBtu			0.06								

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Organic Compound Emissions Methane	Nonmethane	Total HC (as CH4)	Benzene	Toluene	Xylenes	Propylene	1,3 Butadiene	Formaldehyde	Acetaldehyde	Acrolein
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph			0.16								
Engine 12				lb/Mgal			7								
Section 3.4				lb/MMBtu			0.05								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph			0.40								
Engine 26				lb/Mgal			17								
Section 3.4				lb/MMBtu			0.12								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph			0.50								
Engine 27				lb/Mgal			23								
Section 3.4				lb/MMBtu			0.17								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph			0.30								
Engine 35				lb/Mgal			12								
Section 3.4				lb/MMBtu			0.09								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph			0.30								
Engine 36				lb/Mgal			13								
Section 3.4				lb/MMBtu			0.10								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph			0.30								
Engine 60				lb/Mgal			13								
Section 3.4				lb/MMBtu			0.10								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph											
Engine 68				lb/Mgal			0								
Section 3.4				lb/MMBtu			0.00								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph			0.25								
Engine 72				lb/Mgal			12								
Section 3.4				lb/MMBtu			0.08								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph			0.22								
Engine 73				lb/Mgal			10								
Section 3.4				lb/MMBtu			0.07								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph			0.22								
Engine 74				lb/Mgal			10								
Section 3.4				lb/MMBtu			0.07								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph			0.40								
Engine 75				lb/Mgal			17								
Section 3.4				lb/MMBtu			0.13								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph			0.22								
Engine 77				lb/Mgal			10								
Section 3.4				lb/MMBtu			0.07								

(1) EMISSIONS OF AIR TOXIC SPECIES: TEST CONDUCTED UNDER AB2588 FOR THE WESTERN STATES PETROLEUM ASSOCIATION BY CARNOT (CR 72600-2061) IN MAY 1990
USING CARB TEST METHODS 100, 410A, 429, & 430

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Organic Compound Emissions Methane	Nonmethane	Total HC (as CH4)	Benzene	Toluene	Xylenes	Propylene	1,3 Butadiene	Formaldehyde	Acetaldehyde	Acrolein

(2) POOLED SOURCE EMISSION TEST REPORT: OIL AND GAS PRODUCTION COMBUSTION SOURCES, FRESNO AND VENTURA COUNTIES, CALIFORNIA BY ENSR CONSULTING AND ENGINEERING (ENSR #7230-007-700) IN DECEMBER 1990
USING CARB TEST METHODS 100, 410A, MODIFIED 429, 430, AND EPA TEST METHOD 18

(3) STANDARDS SUPPORT AND ENVIRONMENTAL IMPACT STATEMENT, VOLUME I: STATIONARY INTERNAL COMBUSTION ENGINES, EPA-450/2-78-125a, U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NC, JULY 1979
USED MODIFIED REFERENCE METHOD 20

(4) ENVIRONMENTAL ASSESSMENT OF NOx CONTROL ON A COMPRESSION IGNITION LARGE BORE RECIPROCATING INTERNAL COMBUSTION ENGINE, VOLUME I: TECHNICAL RESULTS, ACUREX REPORT TR-81-81/EE, APRIL 1984
USED DIESEL ENGINE MANUFACTURERS ASSOCIATION EXHAUST EMISSION MEASUREMENT PROCEDURES

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE		Data Qual.	Fuel	Rating Hp	UNITS	Organic Compound Emissions Methane	Nonmethane	Total HC (as CH4)	Benzene	Toluene	Xylenes	Propylene	1,3 Butadiene	Formaldehyde	Acetaldehyde	Acrolein
SSEIS, Vol. 1	(3)	B	Dual F	711	g/hph			1.50								
Engine 61					lb/Mgal			69								
Section 3.4					lb/MMBtu			0.50								
SSEIS, Vol. 1	(3)	B	Dual F	2,410	g/hph			5.67								
Engine 16					lb/Mgal			265								
Section 3.4					lb/MMBtu			1.93								
SSEIS, Vol. 1	(3)	B	Dual F	4,300	g/hph			5.16								
Engine 6					lb/Mgal			246								
Section 3.4					lb/MMBtu			1.79								
SSEIS, Vol. 1	(3)	B	Dual F	8,658	g/hph			2.10								
Engine 50					lb/Mgal			102								
Section 3.4					lb/MMBtu			0.74								
SSEIS, Vol. 1	(3)	B	Dual F	>350 CID/CYL	g/hph			0.85								
Engine 7					lb/Mgal			40								
Section 3.4					lb/MMBtu			0.29								
SSEIS, Vol. 1	(3)	B	Dual F	>350 CID/CYL	g/hph			1.54								
Engine 13					lb/Mgal			66								
Section 3.4					lb/MMBtu			0.48								
SSEIS, Vol. 1	(3)	B	Dual F	>350 CID/CYL	g/hph			2.66								
Engine 14					lb/Mgal			112								
Section 3.4					lb/MMBtu			0.82								
SSEIS, Vol. 1	(3)	B	Dual F	>350 CID/CYL	g/hph			1.25								
Engine 76					lb/Mgal			61								
Section 3.4					lb/MMBtu			0.44								
SSEIS, Vol. 1	(3)	B	Dual F	>350 CID/CYL	g/hph			1.00								
Engine 78					lb/Mgal			48								
Section 3.4					lb/MMBtu			0.35								

(3) STANDARDS SUPPORT AND ENVIRONMENTAL IMPACT STATEMENT, VOLUME I: STATIONARY INTERNAL COMBUSTION ENGINES, EPA-450/2-78-125a, U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NC, JULY 1979
USED MODIFIED REFERENCE METHOD 20

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wkl

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Particulate size distribution <1 um	1-3 um	3-10 um	>10 um	Total	PARTICULATE EMISSIONS USING METHOD 5 Solids	Condensables	Total
SSEIS, Vol. 1 (3)	B	Diesel	610	g/hph								
Engine 24				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	711	g/hph								
Engine 62				lb/Mgal								
Section 3.4				lb/MMBtu								
AB2588 for WSPA (2)	B	Diesel	850	ug/m3								
Drilling Rig		At 100% load?		ppm								
Section 3.4		hp & hr invalid		ppb								
				lb/hr								
				g/hph								
				lb/Mgal								
				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	1,100	g/hph								
Engine 43				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	1,300	g/hph								
Engine 56				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	1,336	g/hph								
Engine 55				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	1,650	g/hph								
Engine 41				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	1,650	g/hph								
Engine 42				lb/Mgal								
Section 3.4				lb/MMBtu								
ACUREX TR-81-81/EE	A	Diesel	2,100	g/hph	0.1520	0.0004	0.0054	0.0394	0.1972	0.2181	0.0245	0.2426
(4)				lb/Mgal	6.4302	0.0169	0.2284	1.6668	8.3424	9.2265	1.0365	10.2630
Section 3.4				lb/MMBtu	0.0478	0.0001	0.0017	0.0124	0.0620	0.0686	0.0077	0.0763
SSEIS, Vol. 1 (3)	B	Diesel	2,200	g/hph								
Engine 17				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	2,410	g/hph								
Engine 15				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	2,475	g/hph								
Engine 3				lb/Mgal								
Section 3.4				lb/MMBtu								

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Particulate size distribution <1 um	1-3 um	3-10 um	>10 um	Total	PARTICULATE EMISSIONS USING METHOD 5 Solids	Condensables	Total
SSEIS, Vol. 1 (3)	B	Diesel	2,675	g/hph								
Engine 57				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	2,800	g/hph								
Engine 58				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	3,300	g/hph								
Engine 18				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	3,631	g/hph								
Engine 52				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	3,900	g/hph								
Engine 19				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	3,900	g/hph								
Engine 59				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	4,300	g/hph								
Engine 5				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	4,880	g/hph								
Engine 51				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Diesel	7,313	g/hph								
Engine 47				lb/Mgal								
Section 3.4				lb/MMBtu								
THE DATA BELOW IS NOT USED DUE TO THE AMBIGUITY OF THE ENGINE SIZE												
SSEIS, Vol. 1 (3)	C	Diesel >350 CID/CYL		g/hph								
Engine 8				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel >350 CID/CYL		g/hph								
Engine 9				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel >350 CID/CYL		g/hph								
Engine 10				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel >350 CID/CYL		g/hph								
Engine 11				lb/Mgal								
Section 3.4				lb/MMBtu								

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Particulate size distribution <1 um	1-3 um	3-10 um	>10 um	Total	PARTICULATE EMISSIONS USING METHOD 5 Solids	Condensables	Total
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph								
Engine 12				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph								
Engine 26				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph								
Engine 27				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph								
Engine 35				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph								
Engine 36				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph								
Engine 60				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph								
Engine 68				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph								
Engine 72				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph								
Engine 73				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL.	g/hph								
Engine 74				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph								
Engine 75				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph								
Engine 77				lb/Mgal								
Section 3.4				lb/MMBtu								

(1) EMISSIONS OF AIR TOXIC SPECIES: TEST CONDUCTED UNDER AB2588 FOR THE WESTERN STATES PETROLEUM ASSOCIATION BY CARNOT (CR 72600-2061) IN MAY 1990
USING CARB TEST METHODS 100, 410A, 429, & 430

STATIONARY INTERNAL COMBUSTION ENGINES
05/10/92 table.wk1

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Particulate size distribution <1 um	1-3 um	3-10 um	>10 um	Total	PARTICULATE EMISSIONS USING METHOD 5 Solids	Condensables	Total

(2) POOLED SOURCE EMISSION TEST REPORT: OIL AND GAS PRODUCTION COMBUSTION SOURCES, FRESNO AND VENTURA COUNTIES, CALIFORNIA BY ENSR CONSULTING AND ENGINEERING (ENSR #7230-007-700) IN DECEMBER 1990
USING CARB TEST METHODS 100, 410A, MODIFIED 429, 430, AND EPA TEST METHOD 18

(3) STANDARDS SUPPORT AND ENVIRONMENTAL IMPACT STATEMENT, VOLUME I: STATIONARY INTERNAL COMBUSTION ENGINES, EPA-450/2-78-125a, U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NC, JULY 1979
USED MODIFIED REFERENCE METHOD 20

(4) ENVIRONMENTAL ASSESSMENT OF NOx CONTROL ON A COMPRESSION IGNITION LARGE BORE RECIPROCATING INTERNAL COMBUSTION ENGINE, VOLUME I: TECHNICAL RESULTS, ACUREX REPORT TR-81-81/EE, APRIL 1984
USED DIESEL ENGINE MANUFACTURERS ASSOCIATION EXHAUST EMISSION MEASUREMENT PROCEDURES

STATIONARY INTERNAL COMBUSTION ENGINES
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SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Particulate size distribution <1 um	1-3 um	3-10 um	>10 um	Total	PARTICULATE EMISSIONS USING METHOD 5 Solids	Condensables	Total
SSEIS, Vol. 1 (3)	B	Dual F	711	g/hph								
Engine 61				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Dual F	2,410	g/hph								
Engine 16				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Dual F	4,300	g/hph								
Engine 6				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Dual F	8,658	g/hph								
Engine 50				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL	g/hph								
Engine 7				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL	g/hph								
Engine 13				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL	g/hph								
Engine 14				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL	g/hph								
Engine 76				lb/Mgal								
Section 3.4				lb/MMBtu								
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL	g/hph								
Engine 78				lb/Mgal								
Section 3.4				lb/MMBtu								

(3) STANDARDS SUPPORT AND ENVIRONMENTAL IMPACT STATEMENT, VOLUME I: STATIONARY INTERNAL COMBUSTION ENGINES, EPA-450/2-78-125a, U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NC, JULY 1979
USED MODIFIED REFERENCE METHOD 20

STATIONARY INTERNAL COMBUSTION ENGINES
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Polycyclic Aromatic Hydrocarbon Emissions (page 1)

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene
SSEIS, Vol. 1 (3)	B	Diesel	610	g/hph										
Engine 24				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	711	g/hph										
Engine 62				lb/Mgal										
Section 3.4				lb/MMBtu										
AB2588 for WSPA (2)	B	Diesel	850	ug/m3	116.81	8.27	4.19	11.49	36.58	1.11	3.62	3.33	0.56	1.37
Drilling Rig		At 100% load?		ppm										
Section 3.4		hp & hr invalid		ppb										
				lb/hr										
				g/hph										
				lb/Mgal	0.0180	0.0013	0.0006	0.0018	0.0056	0.0002	0.0006	0.0005	0.0001	0.0002
				lb/MMBtu	1.30E-04	9.23E-06	4.68E-06	1.28E-05	4.08E-05	1.23E-06	4.03E-06	3.71E-06	6.22E-07	1.53E-06
SSEIS, Vol. 1 (3)	B	Diesel	1,100	g/hph										
Engine 43				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	1,300	g/hph										
Engine 56				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	1,336	g/hph										
Engine 55				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	1,650	g/hph										
Engine 41				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	1,650	g/hph										
Engine 42				lb/Mgal										
Section 3.4				lb/MMBtu										
ACUREX TR-81-81/EE	A	Diesel	2,100	g/hph										
(4)				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	2,200	g/hph										
Engine 17				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	2,410	g/hph										
Engine 15				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	2,475	g/hph										
Engine 3				lb/Mgal										
Section 3.4				lb/MMBtu										

STATIONARY INTERNAL COMBUSTION ENGINES
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Polycyclic Aromatic Hydrocarbon Emissions (page 1)

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene
SSEIS, Vol. 1 (3)	B	Diesel	2,675	g/hph										
Engine 57				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	2,800	g/hph										
Engine 58				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	3,300	g/hph										
Engine 18				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	3,631	g/hph										
Engine 52				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	3,900	g/hph										
Engine 19				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	3,900	g/hph										
Engine 59				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	4,300	g/hph										
Engine 5				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	4,880	g/hph										
Engine 51				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	B	Diesel	7,313	g/hph										
Engine 47				lb/Mgal										
Section 3.4				lb/MMBtu										
THE DATA BELOW IS NOT USED DUE TO THE AMBIGUITY OF THE ENGINE SIZE														
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 8				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 9				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 10				lb/Mgal										
Section 3.4				lb/MMBtu										
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 11				lb/Mgal										
Section 3.4				lb/MMBtu										

STATIONARY INTERNAL COMBUSTION ENGINES
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Polycyclic Aromatic Hydrocarbon Emissions (page 1)

SOURCE		Data Qual.	Fuel	Rating Hp	UNITS	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene
SSEIS, Vol. 1	(3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 12					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 26					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 27					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 35					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 36					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 60					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 68					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 72					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 73					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 74					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 75					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	C	Diesel	>350 CID/CYL	g/hph										
Engine 77					lb/Mgal										
Section 3.4					lb/MMBtu										

(1) EMISSIONS OF AIR TOXIC SPECIES: TEST CONDUCTED UNDER AB2588 FOR THE WESTERN STATES PETROLEUM ASSOCIATION BY CARNOT (CR 72600-2061) IN MAY 1990
USING CARB TEST METHODS 100, 410A, 429, & 430

STATIONARY INTERNAL COMBUSTION ENGINES
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Polycyclic Aromatic Hydrocarbon Emissions (page 1)

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene

(2) POOLED SOURCE EMISSION TEST REPORT: OIL AND GAS PRODUCTION COMBUSTION SOURCES, FRESNO AND VENTURA COUNTIES, CALIFORNIA BY ENSR CONSULTING AND ENGINEERING (ENSR #7230-007-700) IN DECEMBER 1990
USING CARB TEST METHODS 100, 410A, MODIFIED 429, 430, AND EPA TEST METHOD 18

(3) STANDARDS SUPPORT AND ENVIRONMENTAL IMPACT STATEMENT, VOLUME I: STATIONARY INTERNAL COMBUSTION ENGINES, EPA-450/2-78-125a, U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NC, JULY 1979
USED MODIFIED REFERENCE METHOD 20

(4) ENVIRONMENTAL ASSESSMENT OF NOx CONTROL ON A COMPRESSION IGNITION LARGE BORE RECIPROCATING INTERNAL COMBUSTION ENGINE, VOLUME I: TECHNICAL RESULTS, ACUREX REPORT TR-81-81/EE, APRIL 1984
USED DIESEL ENGINE MANUFACTURERS ASSOCIATION EXHAUST EMISSION MEASUREMENT PROCEDURES

STATIONARY INTERNAL COMBUSTION ENGINES
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Polycyclic Aromatic Hydrocarbon Emissions (page 1)

SOURCE		Data Qual.	Fuel	Rating Hp	UNITS	Naphthalene	Acenaphthylene	Acenaphthene	Fluorene	Phenanthrene	Anthracene	Fluoranthene	Pyrene	Benz(a)anthracene	Chrysene
SSEIS, Vol. 1	(3)	B	Dual F	711	g/hph										
Engine 61					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	B	Dual F	2,410	g/hph										
Engine 16					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	B	Dual F	4,300	g/hph										
Engine 6					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	B	Dual F	8,658	g/hph										
Engine 50					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	B	Dual F	>350 CID/CYL	g/hph										
Engine 7					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	B	Dual F	>350 CID/CYL	g/hph										
Engine 13					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	B	Dual F	>350 CID/CYL	g/hph										
Engine 14					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	B	Dual F	>350 CID/CYL	g/hph										
Engine 76					lb/Mgal										
Section 3.4					lb/MMBtu										
SSEIS, Vol. 1	(3)	B	Dual F	>350 CID/CYL	g/hph										
Engine 78					lb/Mgal										
Section 3.4					lb/MMBtu										

(3) STANDARDS SUPPORT AND ENVIRONMENTAL IMPACT STATEMENT, VOLUME I: STATIONARY INTERNAL COMBUSTION ENGINES, EPA-450/2-78-125a, U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NC, JULY 1979
USED MODIFIED REFERENCE METHOD 20

STATIONARY INTERNAL COMBUSTION ENGINES
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Polycyclic Aromatic Hydrocarbon Emissions (page 2)

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenz(a,h)anthracene	Benzo(g,h,l)perylene
SSEIS, Vol. 1 (3) Engine 24 Section 3.4	B	Diesel	610	g/hph						
				lb/Mgal						
				lb/MMBtu						
SSEIS, Vol. 1 (3) Engine 62 Section 3.4	B	Diesel	711	g/hph						
				lb/Mgal						
				lb/MMBtu						
AB2588 for WSPA (2) Drilling Rig Section 3.4	B	Diesel At 100% load? hp & hr invalid	850	ug/m3	1	< 0.2	< 0.23	< 0.37	< 0.31	< 0.5
				ppm						
				ppb						
				lb/hr						
				g/hph						
				lb/Mgal	0.0002	< 0.00003	< 0.00004	< 0.0001	< 0.00005	< 0.0001
				lb/MMBtu	1.11E-06	< 2.18E-07	< 2.57E-07	< 4.14E-07	< 3.46E-07	< 5.56E-07
SSEIS, Vol. 1 (3) Engine 43 Section 3.4	B	Diesel	1,100	g/hph						
				lb/Mgal						
				lb/MMBtu						
SSEIS, Vol. 1 (3) Engine 56 Section 3.4	B	Diesel	1,300	g/hph						
				lb/Mgal						
				lb/MMBtu						
SSEIS, Vol. 1 (3) Engine 55 Section 3.4	B	Diesel	1,336	g/hph						
				lb/Mgal						
				lb/MMBtu						
SSEIS, Vol. 1 (3) Engine 41 Section 3.4	B	Diesel	1,650	g/hph						
				lb/Mgal						
				lb/MMBtu						
SSEIS, Vol. 1 (3) Engine 42 Section 3.4	B	Diesel	1,650	g/hph						
				lb/Mgal						
				lb/MMBtu						
ACUREX TR-81-81/EE (4) Section 3.4	A	Diesel	2,100	g/hph						
				lb/Mgal						
				lb/MMBtu						
SSEIS, Vol. 1 (3) Engine 17 Section 3.4	B	Diesel	2,200	g/hph						
				lb/Mgal						
				lb/MMBtu						
SSEIS, Vol. 1 (3) Engine 15 Section 3.4	B	Diesel	2,410	g/hph						
				lb/Mgal						
				lb/MMBtu						
SSEIS, Vol. 1 (3) Engine 3 Section 3.4	B	Diesel	2,475	g/hph						
				lb/Mgal						
				lb/MMBtu						

STATIONARY INTERNAL COMBUSTION ENGINES
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Polycyclic Aromatic Hydrocarbon Emissions (page 2)

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenz(a,h)anthracene	Benzo(g,h,l)perylene
SSEIS, Vol. 1 (3)	B	Diesel	2,675	g/hph						
Engine 57				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Diesel	2,800	g/hph						
Engine 58				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Diesel	3,300	g/hph						
Engine 18				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Diesel	3,631	g/hph						
Engine 52				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Diesel	3,900	g/hph						
Engine 19				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Diesel	3,900	g/hph						
Engine 59				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Diesel	4,300	g/hph						
Engine 5				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Diesel	4,880	g/hph						
Engine 51				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Diesel	7,313	g/hph						
Engine 47				lb/Mgal						
Section 3.4				lb/MMBtu						
THE DATA BELOW IS NOT USED DUE TO THE AMBIGUITY OF THE ENGINE SIZE										
SSEIS, Vol. 1 (3)	C	Diesel >350 CID/CYL		g/hph						
Engine 8				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel >350 CID/CYL		g/hph						
Engine 9				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel >350 CID/CYL		g/hph						
Engine 10				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel >350 CID/CYL		g/hph						
Engine 11				lb/Mgal						
Section 3.4				lb/MMBtu						

STATIONARY INTERNAL COMBUSTION ENGINES
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Polycyclic Aromatic Hydrocarbon Emissions (page 2)

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenz(a,h)anthracene	Benzo(g,h,i)perylene
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph						
Engine 12				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph						
Engine 26				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph						
Engine 27				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph						
Engine 35				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph						
Engine 36				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph						
Engine 60				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph						
Engine 68				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph						
Engine 72				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph						
Engine 73				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph						
Engine 74				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph						
Engine 75				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	C	Diesel	>350 CID/CYL	g/hph						
Engine 77				lb/Mgal						
Section 3.4				lb/MMBtu						

(1) EMISSIONS OF AIR TOXIC SPECIES: TEST CONDUCTED UNDER AB2588 FOR THE WESTERN STATES PETROLEUM ASSOCIATION BY CARNOT (CR 72600-2061) IN MAY 1990
USING CARB TEST METHODS 100, 410A, 429, & 430

STATIONARY INTERNAL COMBUSTION ENGINES
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Polycyclic Aromatic Hydrocarbon Emissions (page 2)

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenz(a,h)anthracene	Benzo(g,h,i)perylene

(2) POOLED SOURCE EMISSION TEST REPORT: OIL AND GAS PRODUCTION COMBUSTION SOURCES, FRESNO AND VENTURA COUNTIES, CALIFORNI
BY ENSR CONSULTING AND ENGINEERING (ENSR #7230-007-700) IN DECEMBER 1990
USING CARB TEST METHODS 100, 410A, MODIFIED 429, 430, AND EPA TEST METHOD 18

(3) STANDARDS SUPPORT AND ENVIRONMENTAL IMPACT STATEMENT, VOLUME I: STATIONARY INTERNAL COMBUSTION ENGINES,
EPA-450/2-78-125a, U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NC, JULY 1979
USED MODIFIED REFERENCE METHOD 20

(4) ENVIRONMENTAL ASSESSMENT OF NOx CONTROL ON A COMPRESSION IGNITION LARGE BORE RECIPROCATING INTERNAL COMBUSTION ENGINE,
VOLUME I: TECHNICAL RESULTS, ACUREX REPORT TR-81-81/EE, APRIL 1984
USED DIESEL ENGINE MANUFACTURERS ASSOCIATION EXHAUST EMISSION MEASUREMENT PROCEDURES

STATIONARY INTERNAL COMBUSTION ENGINES
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Polycyclic Aromatic Hydrocarbon Emissions (page 2)

SOURCE	Data Qual.	Fuel	Rating Hp	UNITS	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(a)pyrene	Indeno(1,2,3-cd)pyrene	Dibenz(a,h)anthracene	Benzo(g,h,l)perylene
SSEIS, Vol. 1 (3)	B	Dual F	711	g/hph						
Engine 61				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Dual F	2,410	g/hph						
Engine 16				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Dual F	4,300	g/hph						
Engine 6				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Dual F	8,658	g/hph						
Engine 50				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL	g/hph						
Engine 7				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL	g/hph						
Engine 13				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL	g/hph						
Engine 14				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL	g/hph						
Engine 76				lb/Mgal						
Section 3.4				lb/MMBtu						
SSEIS, Vol. 1 (3)	B	Dual F	>350 CID/CYL	g/hph						
Engine 78				lb/Mgal						
Section 3.4				lb/MMBtu						

(3) STANDARDS SUPPORT AND ENVIRONMENTAL IMPACT STATEMENT, VOLUME I: STATIONARY INTERNAL COMBUSTION ENGINES, EPA-450/2-78-125a, U. S. ENVIRONMENTAL PROTECTION AGENCY, RESEARCH TRIANGLE PARK, NC, JULY 1979
USED MODIFIED REFERENCE METHOD 20

Match 1 DB Rec# - 2,335 Dataset-Voc Emission Factor Tables

VOC EFACTOR Profile Number : 0008
VOC EFACTOR Profile Descr. : Reciprocating Diesel Fuel Engine

VOC EFACTOR Profile Quality : C
VOC EFACTOR Profile Source :
Composite profile developed using data based on GC/MS
analysis of fuel combustion exhaust.
VOC EFACTOR Profile Control : Uncontrolled

VOC EFACTOR Profile Date : 01/05/89
VOC EFACTOR Profile Refs :58 | 60
VOC EFACTOR Units : LBS PER 1000 GALLONS BURNED

VOC EFACTOR CAS numbers :
71-43-2 | 74-82-8 | 74-84-0 | 74-85-1 | 74-86-2 | 106-98-9 | 106-99-0 |
115-07-1 |
VOC EFACTOR SCC : 20200401
VOC EFACTOR SCC Description : INTERNLCOMBUSTION INDUSTRIAL LARGE BORE EN
GINE DIESEL
VOC EFACTOR SCC Assignment : Original
VOC EFACTOR Table :

VOC Speciated Emission Factor Profile

CAS Number	Name	Emmision Factor
71-43-2	BENZENE	1.027000
74-82-8	METHANE	1.508000
74-84-0	ETHANE	0.364000
74-85-1	ETHYLENE	3.731000
74-86-2	ACETYLENE	1.469000
106-98-9	BUTENE	1.742000
[illegible]-99-0	1,3-BUTADIENE	0.910000
[illegible]07-1	PROPENE	2.249000

Match 10 DB Rec# - 32,674 Dataset-Voc Profiles

VOC PROFILE Number : 0008
VOC PROFILE Description : Reciprocating Diesel Fuel Engine

VOC PROFILE Quality : C
VOC PROFILE Control : Uncontrolled

VOC PROFILE References :58 | 60
VOC PROFILE Date : 01/05/89
VOC PROFILE Source :
Composite profile developed using data based on GC/MS analysis of fuel combustion exhaust.
VOC PROFILE Original SCC :
20200401 | 20400402 |
VOC PROFILE CAS numbers :
71-43-2 | 74-82-8 | 74-84-0 | 74-85-1 | 74-86-2 | 106-98-9 | 106-99-0 | 115-07-1 |
VOC PROFILE Table :

VOC Profile Speciation Report
Control Device : Uncontrolled

CAS Number	Name	Spec_MW	Spec_WT	Peak
-43-2	BENZENE	78.11	7.90	
74-82-8	METHANE	16.04	11.60	
74-84-0	ETHANE	30.07	2.80	
74-85-1	ETHYLENE	28.05	28.70	
74-86-2	ACETYLENE	26.04	11.30	
106-98-9	BUTENE	56.10	13.40	
106-99-0	1,3-BUTADIENE	54.09	7.00	
115-07-1	PROPENE	42.08	17.30	
TOTAL			100.00	

Match 1 DB Rec# - 2,356 Dataset-Voc Emission Factor Tables

C EFACTOR Profile Number : 0008
C EFACTOR Profile Descr. : Reciprocating Diesel Fuel Engine

VOC EFACTOR Profile Quality : C
VOC EFACTOR Profile Source :
Composite profile developed using data based on GC/MS analysis of fuel combustion exhaust.
VOC EFACTOR Profile Control : Uncontrolled

VOC EFACTOR Profile Date : 01/05/89
VOC EFACTOR Profile Refs :58 | 60
VOC EFACTOR Units : LBS PER 1000 GALLONS BURNED

VOC EFACTOR CAS numbers :
71-43-2 | 74-82-8 | 74-84-0 | 74-85-1 | 74-86-2 | 106-98-9 | 106-99-0 | 115-07-1 |
VOC EFACTOR SCC : 20400402
VOC EFACTOR SCC Description : INTERNLCOMBUSTION ENGINE TESTING RECIPROCATING DIESEL/KEROSENE
VOC EFACTOR SCC Assignment : Original
VOC EFACTOR Table :

VOC Speciated Emission Factor Profile

S Number	Name	Emmision Factor
71-43-2	BENZENE	2.535900
74-82-8	METHANE	3.723600
74-84-0	ETHANE	0.898800
74-85-1	ETHYLENE	9.212700
74-86-2	ACETYLENE	3.627300
106-98-9	BUTENE	4.301400
106-99-0	1,3-BUTADIENE	2.247000
115-07-1	PROPENE	5.553300

Match 6 DB Rec# - 38,042 Dataset-Sources

urce Classification Code :20400402
.C Description :INTERNLCOMBUSTION ENGINE TESTING RECIPROCATING
DIESEL/KEROSENE
Emission Factor Units :LBS PER 1000 GALLONS BURNED
Tot Susp Part Emm Factor :33.50000000
Volatile Org Comp Emm Factor :32.10000000

Match 6 DB Rec# - 38,041 Dataset-Sources

urce Classification Code :20400401
.C Description :INTERNLCOMBUSTION ENGINE TESTING RECIPROCATING
GASOLINE
Emission Factor Units :LBS PER 1000 GALLONS BURNED
Tot Susp Part Emm Factor :6.47000000
Volatile Org Comp Emm Factor :148.00000000

Match 6 DB Rec# - 38,029 Dataset-Sources

urce Classification Code :20300301
.C Description :INTERNLCOMBUSTION COMMERCL-INSTUTNL GASOLINE RECIPROCATING
Emission Factor Units :LBS PER 1000 GALLONS BURNED
Tot Susp Part Emm Factor :6.47000000
Volatile Org Comp Emm Factor :147.70000000

Match 6 DB Rec# - 38,003 Dataset-Sources

urce Classification Code :20100902
SCC Description :INTERNLCOMBUSTION ELECTRIC GENERATN KERONAPTHA JET FL RECIPROCATING
Emission Factor Units :LBS PER 1000 GALLONS BURNED
Tot Susp Part Emm Factor :33.50000000
Volatile Org Comp Emm Factor :32.10000000

Match 12 DB Rec# - 38,016 Dataset-Sources

urce Classification Code :20200402
..C Description :INTERNLCOMBUSTION INDUSTRIAL LARGE BORE ENG
INE DUAL FUEL(OIL/GAS
Emission Factor Units :LBS PER 1000 HORSEPOWER-HOURS
Tot Susp Part Emm Factor :2.20000000
Volatile Org Comp Emm Factor :1.50000000

Match 6 DB Rec# - 38,017 Dataset-Sources

urce Classification Code :20200403
..C Description :INTERNLCOMBUSTION INDUSTRIAL LARGE BORE ENG
INE COGNTRN-DUAL FUEL
Emission Factor Units :LBS PER 100000 BRAKE HORSE-POWER HOURS
Tot Susp Part Emm Factor :.03500000
Volatile Org Comp Emm Factor :1.32000000

Match 12 DB Rec# - 38,015 Dataset-Sources

urce Classification Code :20200401
--C Description :INTERNLCOMBUSTION INDUSTRIAL LARGE BORE ENG
INE DIESEL
Emission Factor Units :LBS PER 1000 GALLONS BURNED
Tot Susp Part Emm Factor :50.00000000
Volatile Org Comp Emm Factor :13.00000000

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

DEC 18 1981

AP-42
3.3.4

Mr. Alan P. Whaerry
Diesel Engine Manufacturer's Association
712 Lakewood Center
14600 Detroit Avenue
Cleveland, Ohio 44107

Dear Mr. Whaerry:

Enclosed is an update of a section that we propose to publish in a supplement to AP-42, Compilation of Air Pollutant Emission Factors, in early 1982. Also included are background materials that show how the emission factors in this section were derived. As mentioned in Bill Lamason's earlier telephone contact with you, we would like your organization's comments on the technical basis for the factors and the approach used in deriving them.

As you probably know, AP-42 is widely used by the U.S. Environmental Protection Agency (EPA), State and local air pollution agencies and industry for developing emission inventories and emission estimates for particular sources. It is increasingly used as a tool in a variety of air quality management applications, including modeling, new source review and enforcement. Hence, it is important that AP-42 have as sound a technical basis as possible.

We are targeting publication of this section for early 1982. To meet this deadline, we would appreciate receiving your comments by March 1, 1982, which allows approximately two months for your review. Unfortunately, because of printing limitations in effect at EPA, we are unable to provide more than one copy of the proposed section and background document. Please direct all review comments (or any questions) to James H. Southerland who is Chief of the Source Analysis Section within my Division and directly responsible for the publication of AP-42. We thank you for your time and consideration on this matter.

Sincerely yours,

Signed

Richard G. Rhoads
Director
Monitoring and Data Analysis Division

Enclosures

cc: J. O'Connor
J. Southerland
B. Lamason

AMTB/SAS/B.LAMASON/cb - Ext. 5585/MD (12/18/81)

CONCURRENCES

SYMBOL	SAS	AMTB						
SURNAME	LAMASON	O'Connor						
DATE	18Dec81	12/18/81						

EPA Form 1320-1 (12-70) OFFICIAL FILE COPY

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

DEC 18 1981

Mr. Richard Ayres
Natural Resources Defense Council
1725 I Street, NW
Suite 600
Washington, DC 20006

Dear Mr. Ayres:

Enclosed are updates of several sections that we propose to publish as supplements to AP-42, Compilation of Air Pollutant Emission Factors, in early 1982. Also included are background materials that show how the emission factors in these sections were derived. As mentioned in my earlier telephone contact with you, we would like your organization's comments on the technical basis for the factors and the approach used in deriving them.

As you probably know, AP-42 is widely used by the U.S. Environmental Protection Agency (EPA), State and local air pollution agencies and industry for developing emission inventories and emission estimates for particular sources. It is increasingly used as a tool in a variety of air quality management applications, including modeling, new source review and enforcement. Hence, it is important that AP-42 have as sound a technical basis as possible.

We are targeting publication of these sections for early 1982. To meet this deadline, we would appreciate receiving your comments by March 1, 1982, which allows approximately two months for your review. Unfortunately, because of printing limitations in effect at EPA, we are unable to provide more than one copy of each proposed section and background document. Please direct all review comments (or any questions) to James H. Southerland who is Chief of the Source Analysis Section within my Division and directly responsible for the publication of AP-42. We thank you for your time and consideration on this matter.

Sincerely yours,

Dick

Richard G. Rhoads
Director
Monitoring and Data Analysis Division

Enclosures

cc: J. O'Connor
J. Southerland
B. Lamason

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

DEC 18 1981

Mr. Carl Pope
Sierra Club
530 Bush Street
San Francisco, California 94108

Dear Mr. Pope:

Enclosed are updates of several sections that we propose to publish as supplements to AP-42, Compilation of Air Pollutant Emission Factors, in early 1982. Also included are background materials that show how the emission factors in these sections were derived. As mentioned in Bill Lamason's earlier telephone contact with you, we would like your organization's comments on the technical basis for the factors and the approach used in deriving them.

As you probably know, AP-42 is widely used by the U.S. Environmental Protection Agency (EPA), State and local air pollution agencies and industry for developing emission inventories and emission estimates for particular sources. It is increasingly used as a tool in a variety of air quality management applications, including modeling, new source review and enforcement. Hence, it is important that AP-42 have as sound a technical basis as possible.

We are targeting publication of these sections for early 1982. To meet this deadline, we would appreciate receiving your comments by March 1, 1982, which allows approximately two months for your review. Unfortunately, because of printing limitations in effect at EPA, we are unable to provide more than one copy of each proposed section and background document. Please direct all review comments (or any questions) to James H. Southerland who is Chief of the Source Analysis Section within my Division and directly responsible for the publication of AP-42. We thank you for your time and consideration on this matter.

Sincerely yours,

Richard G. Rhoads
Director
Monitoring and Data Analysis Division

8 Enclosures

cc: B. Lamason, AMTB
J. Southerland, AMTB

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

DEC 18 1981

Mr. Thomas C. Young, Executive Director
Engine Manufacturers Association
111 E. Wacker Drive
Chicago, Illinois 60601

Dear Mr. Young:

Enclosed is an update of a section that we propose to publish in a supplement to AP-42, Compilation of Air Pollutant Emission Factors, in early 1982. Also included are background materials that show how the emission factors in this section were derived. As mentioned in Bill Lamason's earlier telephone contact with you, we would like your organization's comments on the technical basis for the factors and the approach used in deriving them.

As you probably know, AP-42 is widely used by the U.S. Environmental Protection Agency (EPA), State and local air pollution agencies and industry for developing emission inventories and emission estimates for particular sources. It is increasingly used as a tool in a variety of air quality management applications, including modeling, new source review and enforcement. Hence, it is important that AP-42 have as sound a technical basis as possible.

We are targeting publication of this section for early 1982. To meet this deadline, we would appreciate receiving your comments by March 1, 1982, which allows approximately two months for your review. Unfortunately, because of printing limitations in effect at EPA, we are unable to provide more than one copy of the proposed section and background document. Please direct all review comments (or any questions) to James H. Southerland who is Chief of the Source Analysis Section within my Division and directly responsible for the publication of AP-42. We thank you for your time and consideration on this matter.

Sincerely yours,

Richard G. Rhoads
Director
Monitoring and Data Analysis Division

Enclosure

cc: B. Lamason, AMTB
J. Southerland, AMTB

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

DEC 18 1981

Mr. Alan P. Whaerry
Diesel Engine Manufacturer's Association
712 Lakewood Center
14600 Detroit Avenue
Cleveland, Ohio 44107

Dear Mr. Whaerry:

Enclosed is an update of a section that we propose to publish in a supplement to AP-42, Compilation of Air Pollutant Emission Factors, in early 1982. Also included are background materials that show how the emission factors in this section were derived. As mentioned in Bill Lamason's earlier telephone contact with you, we would like your organization's comments on the technical basis for the factors and the approach used in deriving them.

As you probably know, AP-42 is widely used by the U.S. Environmental Protection Agency (EPA), State and local air pollution agencies and industry for developing emission inventories and emission estimates for particular sources. It is increasingly used as a tool in a variety of air quality management applications, including modeling, new source review and enforcement. Hence, it is important that AP-42 have as sound a technical basis as possible.

We are targeting publication of this section for early 1982. To meet this deadline, we would appreciate receiving your comments by March 1, 1982, which allows approximately two months for your review. Unfortunately, because of printing limitations in effect at EPA, we are unable to provide more than one copy of the proposed section and background document. Please direct all review comments (or any questions) to James H. Southerland who is Chief of the Source Analysis Section within my Division and directly responsible for the publication of AP-42. We thank you for your time and consideration on this matter.

Sincerely yours,

Richard G. Rhoads
Director
Monitoring and Data Analysis Division

Enclosures

cc: J. O'Connor
J. Southerland
B. Lamason

DATE: 8-16-82

AP-42 SECTION REVIEW LOG AND COMMENT SUMMARY

SECTION NO. 3.3.4 TITLE: STATIONARY LARGE BORE DIESEL AND DUAL FUEL ENGINES.

SAS PROJECT OFFICER: LAMASON CONTRACTOR: ACCUREX (ESED) (NO LONGER ON PROJECT)

NATURE AND SUMMARY OF REVISIONS: NEW SECTION

REVIEW LOG

Reviewer/Organization/ Address/Telephone No.	Date Sent	Due Deadline	Date Returned	Remarks (Related to General Review)
ALLEN P. WHERRY DIESEL ENGINE MANUFACTURERS ASSOCIATION 712 LAKEWOOD CENTER NORTH 14600 DETROIT AVE CLEVELAND, OHIO 44107 (216) 226-7700	12/18/81	3/1/82	3/9/82 ADDITIONAL COMMENTS 6/23/82	SEE ATTACHED LETTER & RESPONSES.

Number and use more pages as required. Comments summarized on reverse side.

REVIEWER COMMENT SUMMARY AND RESPONSES: (Reviewer/comments/response)

SEE ATTACHED LETTER

Use additional pages as needed

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

JUL 19 1982

AP-42 #3.3.4

Mr. Allen P. Wherry
Diesel Engine Manufacturers Association
712 Lakewood Center North
14600 Detroit Avenue
Cleveland, Ohio 44107

Dear Mr. Wherry:

Thank you for expressing your continued interest in the development of AP-42 Section 3.3.4, Stationary Large Bore Diesel and Duel Fuel Engines, in letters dated March 9 and June 23. These comments were most welcome and quite timely, in that we expect to complete Section 3.3.4 for publication and distribution by September 30, 1982.

We have reviewed and considered the comments in both letters referring to the discussion of control methods for these engines, which is intended as a primer on control information. We concur with your March 9 comments that the 40 percent reduction from injection retard, and 25 percent reduction with air/fuel ratio adjustment, are not necessarily additive. We will delete the references to a combined control reduction of 65 percent for these measures.

Specifically regarding your additional comments of June 23, we agree that the word "ignition" in the second paragraph of 3.3.4.2 should be "injection". "Engine load", also listed as a variable affecting NO_x emissions in the second paragraph of 3.3.4.2, refers to the effects of derating, not turbocharging. The discussion of air/fuel ratio in the third paragraph of 3.3.4.2 does not refer to engine load. Finally, your statement is true that NO_x reduction by air/fuel ratio depends on where one is on the air/fuel curve and in what direction one moves on the curve. However, we feel this would be obvious to users involved with control design. We feel the existing text serves its intended purpose of identifying air/fuel ratio adjustment as a method of reducing NO_x emissions without bogging down in an excessively detailed technical discussion.

We apologize for our delay in responding to your March 9 letter, but we are presently involved with many AP-42 projects. Thanks again for providing

CONCURRENCES

SYMBOL	SAS	SAS	AQMTB					
SURNAME	Cameron	Southerland	O'Connor					
DATE	7/14/82	7/19/82	7/19/82					

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us with your comments. Should you have any questions concerning our response, please feel free to contact Bill Lamason, Air Management Technology Branch, (919) 541-5585.

Sincerely yours,

John R. O'Connor
Chief
Air Management Technolgy Branch

cc: R. Rhoads, MDAD
D. Bell, RSKD

AMTB:SAS:WHLAMASON:ew:rm832MU:ext.5585:67/12/82

Diesel ENGINE MANUFACTURERS ASSOCIATION

712 LAKEWOOD CENTER NORTH • 14600 DETROIT AVENUE
CLEVELAND, OHIO 44107
(216) 226-7700 • TELEX 98-5559

A. P. WHERRY & ASSOCIATES INC., *Managers*

June 23, 1982

Mr. Richard G. Rhoads, Director
Monitoring and Data Analysis Division
U.S. Environmental Protection Agency
Office of Air Quality Planning and Stds.
Research Triangle Park, NC 27711

SUBJECT: Section 3.3.4 Stationary Large Bore Diesel & Dual Fuel Engines
Supplement to AP-42

Dear Mr. Rhoads:

On March 9, 1982 we wrote to you with our comments on the subject document. At a recent meeting of our Technical Committee, we were requested to determine the current status of this project. We would appreciate knowing its current status and whether or not our comments were accepted.

We are also enclosing for your information a marked up copy of 3.3.4 which contains additional comments received at our recent meeting. Look forward to hearing from you.

Very truly yours,

Allen P. Wherry

ALLEN P. WHERRY

APW:mjp
dema
Enclosure

ccs: B. M. Chrisman, Cooper Energy
L. D. Evans, Dresser-Waukesha

ROUTING AND TRANSMITTAL SLIP

Date 6/29

TO: (Name, office symbol, room number, building, Agency/Post)	Initials	Date
1. AMTB		
2.		
3.		
4.		
5.		

Box From John O
cc to Rhoads
Expect to go to print ~ August
Distribution Sept/Oct
Thanks for comments

X	Action		File		Note and Return
	Approval		For Clearance		Per Conversation
	As Requested		For Correction		Prepare Reply
	Circulate		For Your Information		See Me
	Comment		Investigate		Signature
	Coordination		Justify		

REMARKS

PLEASE RESPOND WITH CC TO ME.

Comments incorporated; etc

OUT BY 7/8/82.

DO NOT use this form as a RECORD of approvals, concurrences, disposals, clearances, and similar actions

FROM: (Name, org. symbol, Agency/Post)	Room No.—Bldg.
Dick	Phone No.

5041-102

OPTIONAL FORM 41 (Rev. 7-76)
Prescribed by GSA
FPMR (41 CFR) 101-11.206

☆GPO : 1981 O - 341-529 (111)

DRAFT

3.3.4 STATIONARY LARGE BORE DIESEL AND DUAL FUEL ENGINES

3.3.4.1 General

The primary domestic use of large bore diesel engines, i.e., those greater than 560 cubic inch displacement per cylinder (CID/CYL), is in oil and gas exploration and production. These engines, in groups of three to five, supply mechanical power to operate drilling (rotary table), mud pumping and hoisting equipment, and may also operate pumps or auxiliary power generators. Another frequent application of large bore diesels is electricity generation for both base and standby service. Smaller uses include irrigation, hoisting and nuclear power plant emergency cooling water pump operation.

Dual fuel engines were developed to obtain compression ignition performance and the economy of natural gas, using a minimum of 5 to 6 percent diesel fuel to ignite the natural gas. Dual fuel large bore engines (greater than 560 CID/CYL) have been used almost exclusively for prime electric power generation.

3.3.4.2 Emissions and Controls

The primary pollutant of concern from large bore diesel and dual fuel engines is NO_x, which readily forms in the high temperature, pressure and excess air environment found in these engines. Lesser amounts of carbon monoxide and hydrocarbons are also emitted. Sulfur dioxide emissions will usually be quite low because of the negligible sulfur content of diesel fuels and natural gas.

injection The major variables affecting NO_x emissions from diesel engines are ignition timing, manifold air temperature, engine speed, engine load and ambient humidity. In general, NO_x emissions decrease with increasing humidity. turbocharging? Cerdy

Because NO_x is the primary pollutant from diesel and dual fuel engines, control measures to date have been directed mainly at limiting NO_x emissions. The most effective NO_x control technique for diesel engines is fuel injection retard, achieving reductions (at eight degrees of retard) of up to 40 percent. Maximum NO_x reductions of about 65 percent are possible with combined retard and air/fuel ratio change. Both retarded fuel injection (8°) and air/fuel ratio change of five percent are also effective in reducing NO_x emissions from dual fuel engines, achieving nominal NO_x reductions of about 40 percent and maximum NO_x reductions of up to 70 percent.

do they mean load

depends on the direction of air/fuel change and where you are on the air/fuel curve

Other NO_x control techniques exist but are not considered feasible because of excessive fuel penalties, capital cost, or maintenance or operational problems. These techniques include

AMTB
Sutherland
Recd
3/15/82
JAB

Diesel ENGINE MANUFACTURERS ASSOCIATION

712 LAKEWOOD CENTER NORTH • 14600 DETROIT AVENUE
CLEVELAND, OHIO 44107
(216) 226-7700 • TELEX 98-5559

A. P. WHERRY & ASSOCIATES INC., *Managers*

March 9, 1982

Mr. Richard G. Rhoads, Director
Monitoring and Data Analysis Division
U.S. Environmental Protection Agency
Office of Air Quality Planning and Stds.
Research Triangle Park, NC 27711

SUBJECT: Section 3.3.4 Stationary Large Bore Diesel & Dual Fuel Engines
Supplement to AP-42

Dear Mr. Rhoads:

On December 18, 1981 you sent us an update of a section which you proposed to publish in a supplement to AP-42, Compilation of Air Pollutant Emission Factors. Our members have reviewed the document, and we submit the following comments:

"In paragraph 3.3.4.2, implication is made that diesel emissions can be reduced by 40% using injection retard, and an additional 25% (to 65% reduction) by air/fuel ratio change. The sentence, 'maximum NO_x reductions of about 65 percent are possible with combined retard and air/fuel ratio change,' should be deleted.

The following points are relevant to this request. Data is taken from the July, 1979 SSEIS.

1. Figure 4-30, page 4-99 (A/F effect, diesel), shows two favorable responses to A/F ratio changes (engines 77 and 60) but fails to show three unfavorable responses (engines 5, 15 and 75). Further, engine 60 had A/F reduced in order to reduce NO_x which increased opacity from 1.4 to an unacceptable 3.6 Bosch.

2. Figure 4-34, page 4-110, (AMT effect, diesel) shows four engines with slight favorable response. Data from engine 55 is questionable since opacity went from 12 to 18 with AMT reduction.

Not shown are engines 15 and 18 which show a reverse NO_x response to AMT reduction.

Unlike the gas and dual-fuel engines, the diesel is quite unresponsive to available NO_x control techniques other than injection retard, and legislation must reflect this."

I trust that our comments will be helpful to you.

Very truly yours,

Allen P. Wherry

ALLEN P. WHERRY

APW:mjp
dema

ccs: B. M. Chrisman, Cooper Energy
L. D. Evans, Dresser-Waukesha

GEOMET, INCORPORATED • 15 FIRSTFIELD ROAD • GAITHERSBURG, MARYLAND 20760
301/948-0755 • CABLE ADDRESS: GEOMETINC

November 22, 1974

Mr. Charles C. Masser
Technical Development Section
National Air Data Branch
U.S. Environmental Protection Agency
Office of Air Quality Planning & Standards
Research Triangle Park, North Carolina 27711

Dear Chuck:

Here is the latest and we hope final version of the Stationary Diesel/Electric Power section. In that connection I would like to bring up a number of points:

1. On the organization of Section 3.3: Sections 3.3.1 and 3.3.3 are already at the printers as you told us; it seems to us that, since utilization of the engine is the determinant, the enclosed section should be a subsection of 3.3.1. Hence the numbers appearing on our draft are only suggestions, temporary, and you will change them as you see fit.

2. To get the emission factors into the units you required, we had to assume an average capacity per unit diesel. You, of course, recognize that an arithmetic average in a sample population with a large capacity range is potentially misleading; in the text; we therefore caution the reader to be careful when he uses this section. If you believe that any of the values are not representative, we will be happy to discuss them with you and if necessary revise the emission factor.

3. With respect to a section on stationary gas turbines and stationary diesels for National Gas Transmission (Section 3.3.2), we hold our previously expressed opinion in our letter of July 31, 1974, which is in agreement with your comments in your letter of September 30, 1974: the available information does not warrant the replacement of Section 3.3.2.

I'm glad that you and Demetri have had such a useful conversation in resolving the difficulties on this section. Finally, still no word from Dennis Naugle since my conversation with John Shipe at Kirtland, in which he said the material should be out in a few days. I plan to call Dennis, unless you want to.

Sincerely,

Scott

Scott D. Thayer
Senior Consulting Scientist

SDT:lr

GEOMET, INCORPORATED • 15 FIRSTFIELD ROAD • GAITHERSBURG, MARYLAND 20760
301/948-0755 • CABLE ADDRESS: GEOMETINC

January 6, 1975

Mr. Charles Masser
National Air Data Branch
Office of Air Quality Planning
and Standards
Environmental Protection Agency
Research Triangle Park, North Carolina 27711

Dear Mr. Masser:

Enclosed is one copy of the Background Documentation under Contract 68-02-1094, Task 8. I am anxious to hear your comments and wish to continue until the final product meets your total satisfaction.

Sincerely,

D. J. Moschandreas, Ph.D.
Research Scientist

DJM/js

Enclosure

U.S. ENVIRONMENTAL PROTECTION AGENCY
Research Triangle Park, North Carolina 27711

2-27-81

DOUG,

THERE ARE SEVERAL MAJOR PROBLEMS W/ THIS SECTION. COMMENTS ARE MARKED ON THE ATTACHED COPIES. THE 1ST COPY CONTAINS TECHNICAL COMMENTS WHILE THE 2ND WAS REVIEWED BY OUR AP42 EDITOR (FOR GRAMMER, FORMAT, ETC.). MOST TECHNICAL PROBLEMS RELATE TO THE REPORTING OF HC EMISSIONS. THOSE EMISSIONS ARE NOW REPORTED AS METHANE AND NONMETHANE VOC. ANOTHER MAJOR PROBLEM IS THE LACK OF A BACKGROUND DOCUMENT SUPPORTING THE DEVELOPED EF'S. IF YOU HAVE ANY QUESTIONS, PLEASE CALL. BILL LAMASON X-5285 (X-5585 AFTER 3/9)

Jim, Bill

This is the first draft of the AP-42 section on large-bore diesel and dual-fuel engines.

This is for review by the appropriate person on your staff. It used to be Chuck Masser but I heard he was leaving.

Please have the person reviewing give me the comments & I'll pass them on to the contractor. Also if it is necessary I will set up a meeting between [redacted] MDAD and the contractor to discuss this section.

Thanks for your help.

Doug Bell (SDB)
(X 5477)

P.S. If possible I'd like to get the comments by 2-27.

3/10/81
Please review & comment to Bill.
Only problem I see at present is HC definition, etc. DWS

U.S. ENVIRONMENTAL PROTECTION AGENCY
Research Triangle Park, North Carolina 27711

Doug, 3-2-81

My second pass on this raised a few more comments. They are marked in blue. I think they indicate why documentation is needed. I looked at the SICE Draft EIS to compare #s w/ Efs. NO_x data may be off a little and # sign. figures may be misleading the user. What is the source of SO_2 data? Let's get accuracy to document better!!

Bill

Jim Laughlin
HMM Associates
782-0824

Call on Monday

ACUREX Corporation

Energy & Environmental Division

March 20, 1981

Bill Lamason (MD-13)
OAQPS/MDAD
U.S. EPA
Research Triangle Park, NC 27711

Dear Bill:

Enclosed find a revised draft of the AP-42 section on stationary large-bore diesel and dual fuel engines along with a draft of the background support document justifying the emission factors noted. These, I believe, address your comments relayed to us at our meeting of March 10. Please relay any further comments you have either to Jim Laughlin of HMM Associates (782-0824), or to Henry Modetz of Acurex.

Sincerely,

Larry R. Waterland
Project Manager

Encl.

cc: Doug Bell (OAQPS/SDB, MD-13)

ACUREX CORPORATION: AEROTHERM GROUP, SOUTH/EAST REGIONAL OPERATIONS
AIRPORT ROAD AT LUMLEY ROAD, RTE. 1, BOX 423, MORRISVILLE, N.C. 27560 PHONE (919) 781-9704

DRAFT

3.3.4 Stationary Large-Bore Diesel and Dual-Fuel Engines

3.3.4.1 General[1] - The primary high usage domestic application of large-bore (i.e., greater than 560 cubic inch displacement per cylinder, CID/CYL) diesel engines is oil and gas exploration and production. These engines, in groups of three to five, supply mechanical power to operate the drilling (rotary table), mud pumping, and hoisting equipment. In other instances, these engines may operate pumps or generator sets for auxiliary power. A secondary high usage application of large-bore diesels is for electrical generation, both base and standby service. Other various small usage applications include irrigation, hoisting, and nuclear power plant emergency cooling water pump operation.

Dual-fuel engines were developed to take advantage of both compression ignition performance and inexpensive natural gas. These engines require a minimum of 5 to 6 percent diesel fuel to ignite the natural gas. Dual-fuel large-bore engines (greater than 560 CID/CYL) have been used almost exclusively for prime electric power generation.

3.3.4.2 Emissions and Controls[1] - The primary pollutant of concern from large-bore diesel and dual-fuel engines is NO_x, which readily forms in the high temperature, pressure, and excess air environment found in these engines. Lesser amounts of carbon monoxide and hydrocarbons are emitted. Sulfur dioxide emissions are proportional to the sulfur content of the fuel and will usually be quite low because of the negligible sulfur content of diesel fuels and natural gas.

The major variables affecting NO_x emissions from diesel engines include ignition timing, manifold air temperature, engine speed, engine load, and ambient humidity. In general, NO_x emissions decrease with increasing humidity.

Because NO_x is the primary pollutant of significance emitted from diesel and dual-fuel engines, control measures to date have been directed mainly at limiting NO_x emissions. The most effective NO_x control technique for diesel engines is fuel injection retard, achieving nominal NO_x reductions (at eight degrees of retard) of 40 percent.[1] Maximum NO_x reductions of about 65 percent are possible with combined retard and air-to-fuel ratio change. Both retarded fuel injection, eight degrees, and air to fuel ratio change, five percent change, are also effective in reducing NO_x emissions from dual-fuel engines, achieving nominal NO_x reductions of about 40 percent, and maximum NO_x reductions of about 70 percent.

Other NO_x control techniques exist but are not considered feasible alternatives because of excessive fuel penalties, capital cost, or maintenance or operational problems. These techniques include exhaust gas recirculation (EGR), combustion chamber modification, water injection, and catalytic reduction.

Emission factors for stationary large-bore diesel and dual-fuel engines are presented in Table 3.3.4.1.

References for Section 3.3.4

1. Standards Support and Environmental Impact Statement Volume I - Stationary Internal Combustion Engines. EPA 450/2-78-125a. Office of Air Quality Planning and Standards, Research Triangle Park, NC. July 1979.

TABLE 3.3.4-1 Emission Factors for Stationary Large-Bore Diesel and Dual-Fuel Engines[a]

	Nitrogen Oxides (as NO_2)[b]	Carbon Monoxide	VOC (as C)[c] Methane	VOC (as C)[c] Nonmethane	Sulfur Dioxide[d]
Diesel Engines	24	6.4	0.07	0.63	7.0
lb/10^3hp-hr	11	2.9	0.03	0.29	3.2
g/hp-hr	15	3.9	0.04	0.39	4.3
g/kW-hr	500	130	1	13	150
lb/10^3gal[e]	60	16	0.2	1.6	18
g/l[e]	—	—	—	—	—
Dual Fuel Engines					
lb/10^3hp-hr	18	5.9	4.7	1.5	0.70
g/hp-hr	8.0	2.7	2.1	0.7	0.32
g/kW-hr	11	3.6	2.9	0.9	0.43

[a]Representative uncontrolled levels for each fuel are determined by weighting data from several manufacturers. Weighting is based on the percentage of total horsepower sold by each manufacturer during a five year period.

[b]These factors are for engines operated at rated load and speed.

[c]Nonmethane VOC accounts for 90 percent of total VOC from diesel engines but only 25 percent of total VOC emissions from dual fuel engines.

[d]Based on an assumed sulfur content of 1 percent by weight for diesel fuel and 0.46 g/scm (0.20 gr/scf) for pipeline quality natural gas. Dual-fuel SO_2 emissions based on 5 percent oil-firing and 95 percent gas-firing. Emissions should be adjusted based on fuel ratio.

[e]These factors are calculated from the above factors assuming a heating value of 40 MJ/l (145,000 Btu/gal) for oil, 41 MJ/scm (1100 Btu/scf) for natural gas, and an average fuel consumption of 9.9 MJ/kW-hr (7000 Btu/hp-hr).

DRAFT

BACKGROUND INFORMATION FOR DEFINING EMISSION FACTORS FOR STATIONARY LARGE-BORE DIESEL AND DUAL-FUEL ENGINES

Uncontrolled emission factors for NO_x, CO, and VOC (both total and nonmethane) for stationary large-bore diesel and dual-fuel engines were derived from engine manufacturer-supplied data. These data exhibited some variability in emissions from engines of different designs. To account for this variability, a sales-weighted average approach was used. The procedure adopted was to compute a weighted average uncontrolled emission level for engines in the diesel and dual-fuel categories. The weighted levels are based on sales of engine horsepower during the past 5 years for domestic applications. Sales of horsepower to standby services were excluded from the computation.

Figures 1 through 6 show uncontrolled emission levels for NO_x, CO, and VOC (with nonmethane VOC noted where measured), taken from engine manufacturer's data. On each figure the data are differentiated by engine design type. Engine types noted are two-stroke, blower scavenged (2-BS), two- and four-stroke turbocharged (2-TC, 4-TC), and four-stroke naturally aspriated (4-NA). NO_x emission data were corrected for ambient temperature and humidity where sufficient data existed.

Also noted in the figures are the sales-weighted average emissions factors calculated. These emission factors for NO_x, CO, and VOC are summarized in Table 1. Note that the sales-weighted average VOC emission factors shown in Figures 5 and 6 are for total VOC emissions. These are split into methane and nonmethane VOC in Table 1 by noting that 90 percent of the VOC emitted from diesel engines and 25 percent of the VOC from dual-fuel engines is nonmethane.

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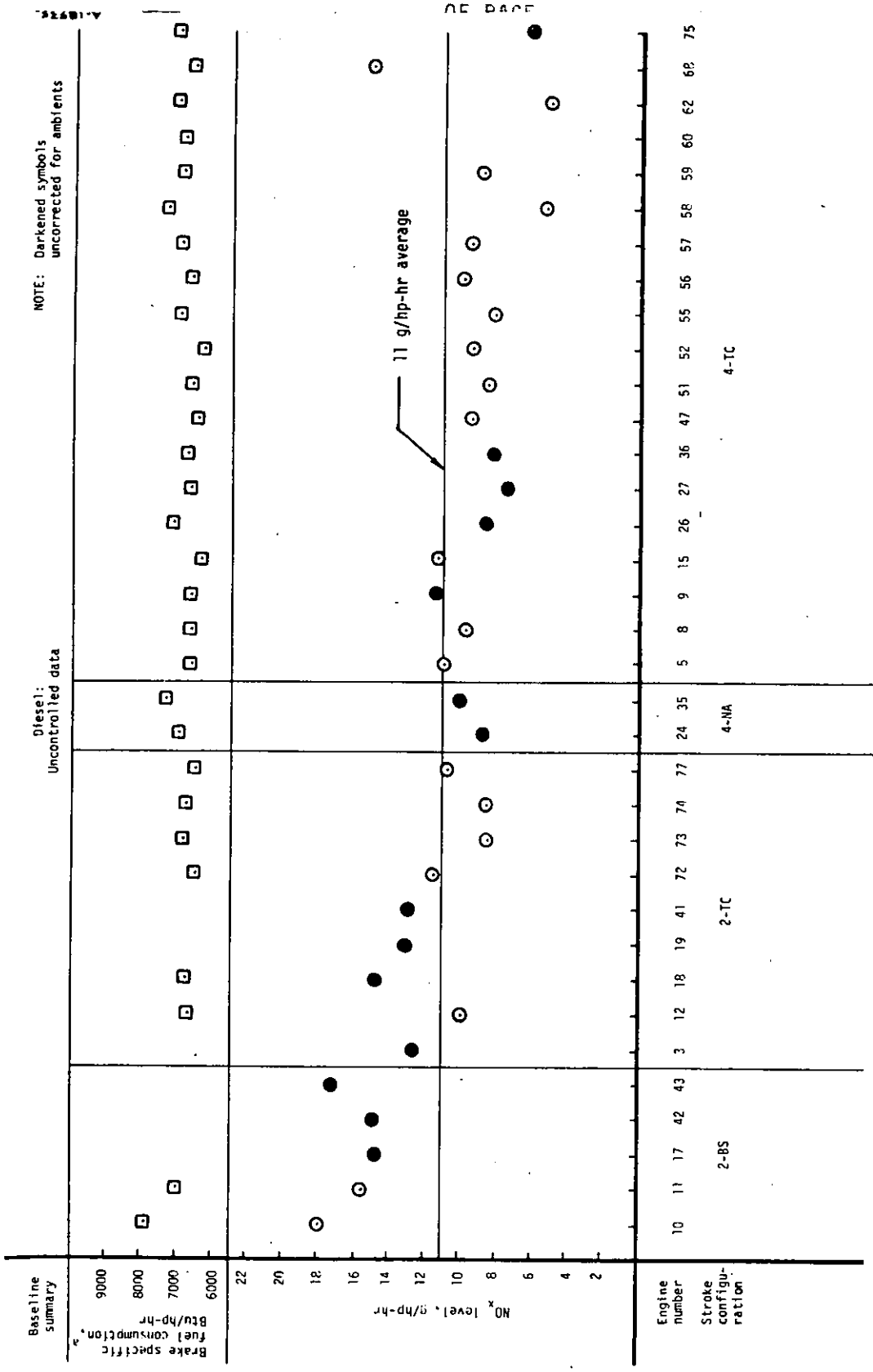

Figure 1. Uncontrolled NO_x emissions from diesel engines.

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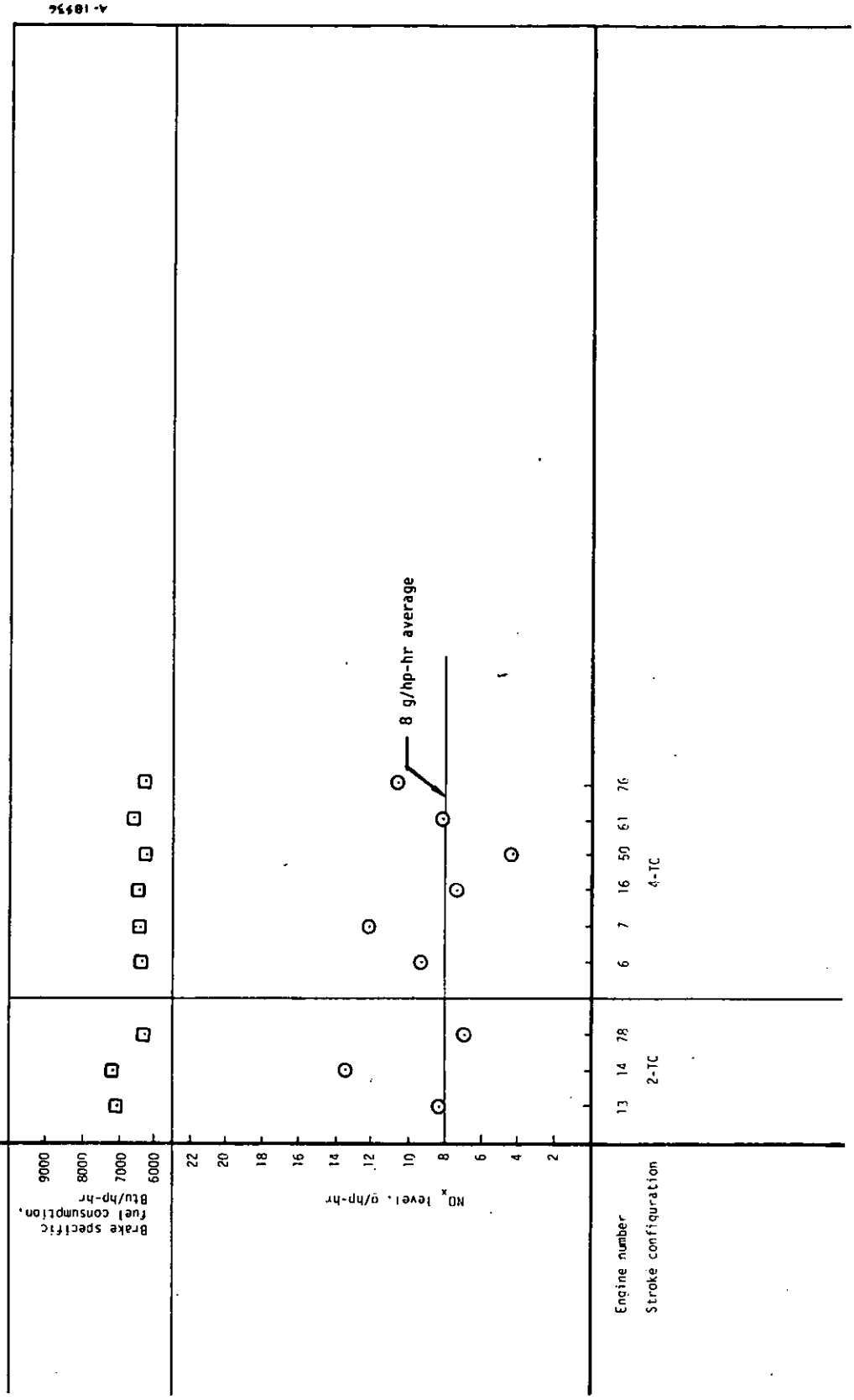

Figure 2. Uncontrolled NO_x emissions from dual fuel engines.

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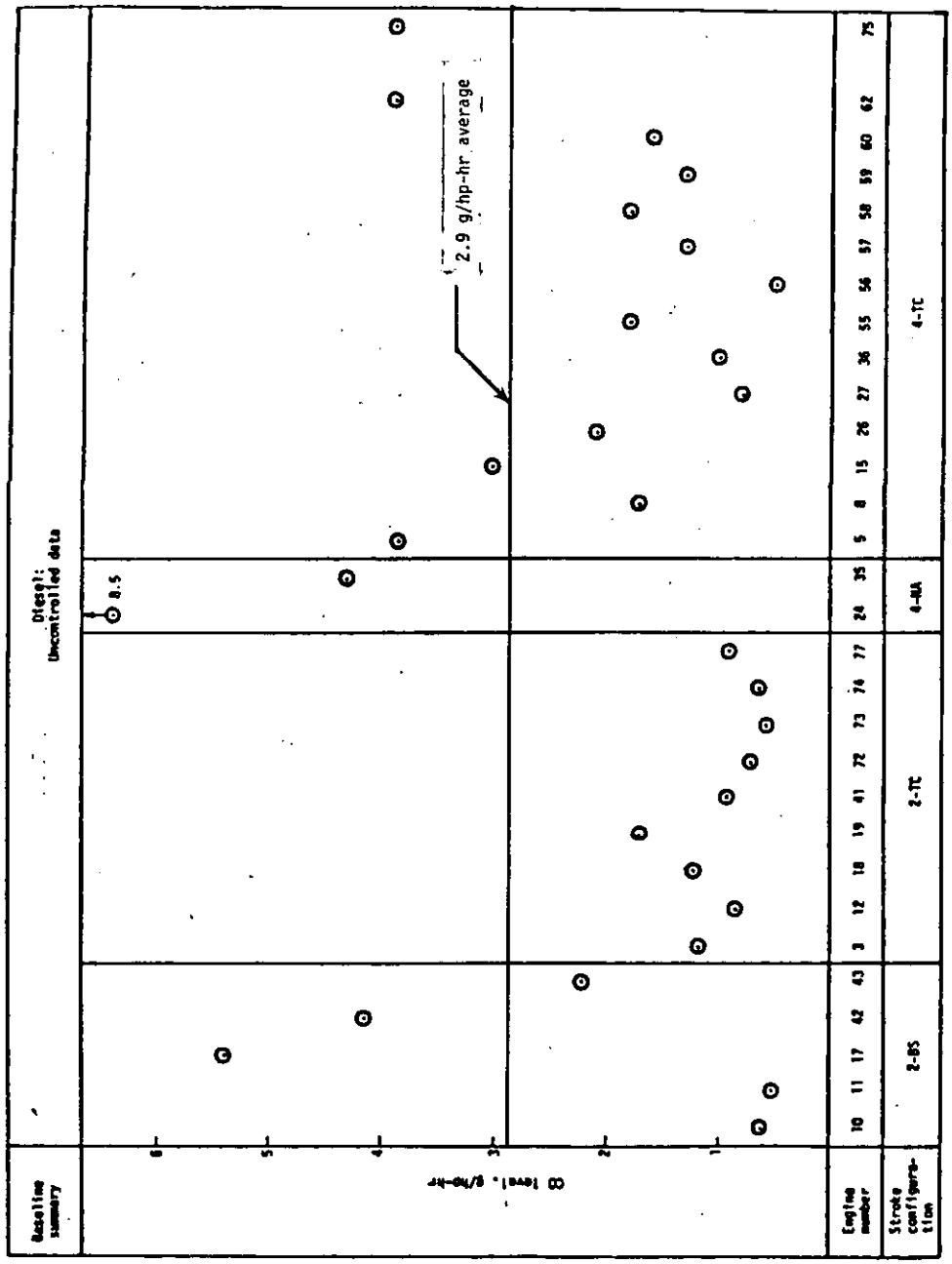

Figure 3. Uncontrolled CO emissions from diesel engines.

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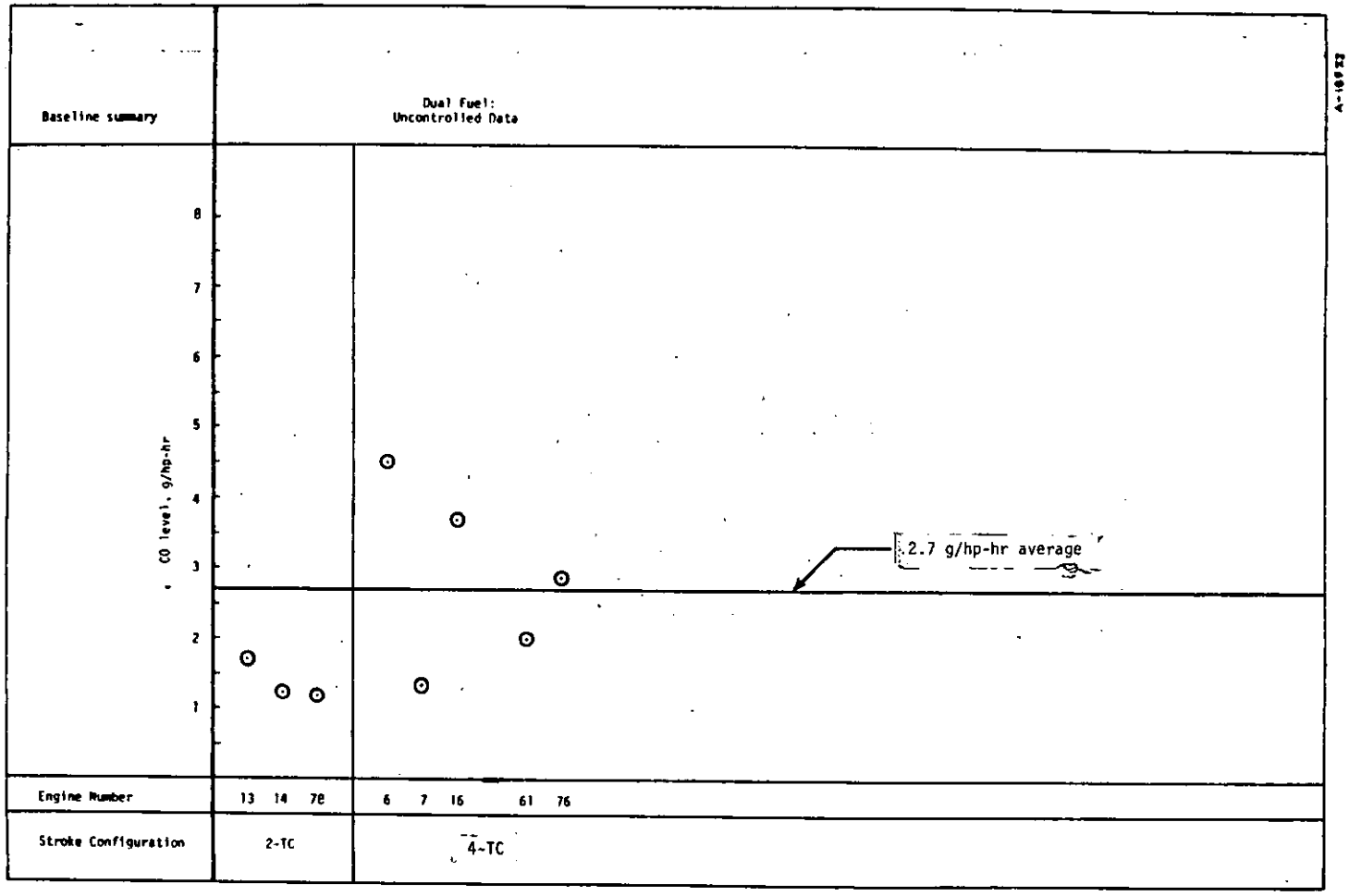

Figure 4. Uncontrolled CO emissions from dual fuel engines.

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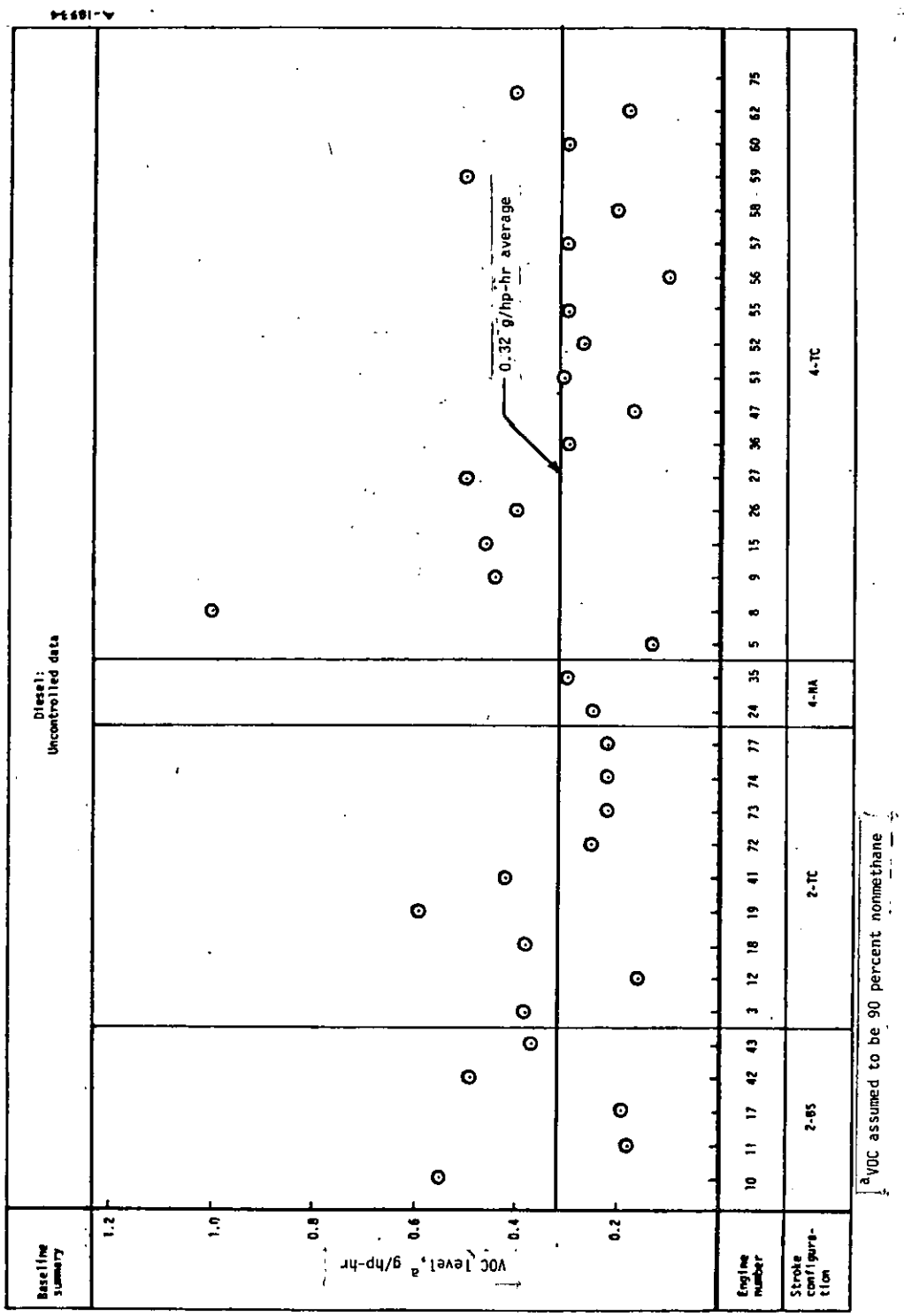

Figure 5. Uncontrolled VOC emissions from diesel engines.

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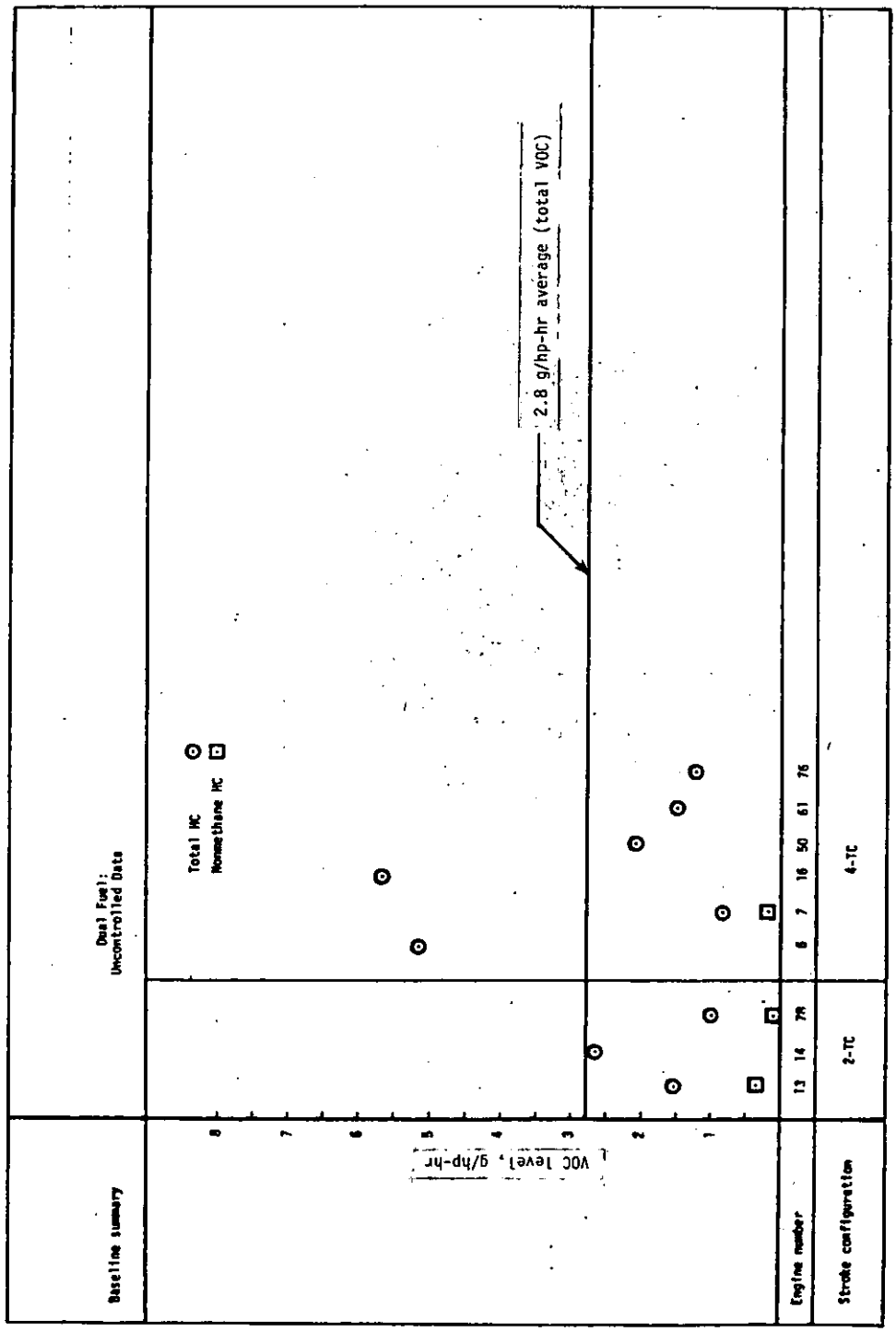

Figure 6. Uncontrolled VOC emissions from dual fuel engines.

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TABLE 1. Sales-Weighted Average Emission Factors for Stationary Large-Bore Diesel and Dual-Fuel Engines (g/hp-hr)

Fuel	NO_x (as NO_2)[a]	CO	VOC (as C)[b] Methane	VOC (as C)[b] Nonmethane	SO_2[c]
Diesel	11	2.9	0.03	0.29	3.2
Dual-Fuel	8.0	2.7	2.1	0.7	0.32

[a]At rated load and speed.

[b]Nonmethane VOC accounts for 90 percent of total VOC from diesel engines and 25 percent of total VOC from dual-fuel engines.

[c]Based on: sulfur content of 1 percent by weight for diesel fuel, 0.46 g/scm (0.20 gr/scf) for natural gas; heating value of 40 MJ/l (145,000 Btu/gal) for diesel fuel, 41 MJ/scm (1100 Btu/scf) for natural gas; average fuel consumption of 7.4 MJ/hp-hr (7000 Btu/hp-hr); and dual-fuel firing 5 percent diesel and 95 percent natural gas.

Table 1 also shows SO_2 emission factors. SO_2 emissions are solely a function of fuel sulfur content. The emission factors in Table 1 assume the sulfur content of diesel fuel is one percent by weight, and of natural gas is 0.46 g/scm (0.20 gr/scf). The heating value of diesel is assumed to be 40 MJ/l (145,000 Btu/gal), and of natural gas to be 41 MJ/scm (1100 Btu/scf). Average fuel consumption is assumed to be 7.4 MJ/hp-hr (7000 Btu/hp-hr), and dual-fuel engines are assumed to burn 5 percent diesel and 95 percent natural gas on a heat input basis.

NEW SECTION

NO BACKGROUND DOCUMENT

DRAFT

JAN 29 '81

Bill Langsen Tech Comments

3.3.4 Stationary Large-Bore Diesel and Dual-Fuel Engines

3.3.4.1 General[1] - The primary high usage domestic application of large-bore (i.e., greater than 560 cubic inch displacement per cylinder, CID/CYL) diesel engines is oil and gas exploration and production. These engines, in groups of three to five, supply mechanical power to operate the drilling (rotary table), mud pumping, and hoisting equipment. In other instances, these engines may operate pumps or generator sets for auxillary power. A secondary high usage application of large-bore diesels is for electrical generation, both base and standby service. Other various small usage applications include irrigation, hoisting, and nuclear power plant emergency cooling water pump operation.

Dual-fuel engines were developed to take advantage of both compression ignition performance and inexpensive natural gas. These engines require a minimum of 5 to 6 percent diesel fuel to ignite the natural gas. These large-bore engines (greater than 560 CID/CYL) have been used almost exclusively for prime electric power generation.

3.3.4.2 Emissions and Controls[1] - The primary pollutant of concern from large-bore diesel and dual-fuel engines is NO_x, which readily forms in the high temperature, pressure, and excess air environment found in these engines. Lesser amounts of carbon monoxide and hydrocarbons are emitted. Sulfur dioxide emissions are proportional to the sulfur content of the fuel and will usually be quite low because of the negligible sulfur content of diesel fuels and natural gas.

The major variables affecting NO_x emissions from diesel engines include ignition timing, manifold air temperature, engine speed, engine load, and ambient humidity. In general, NO_x emissions increase with increasing humidity.

Because NO_x is the primary pollutant of significance emitted from diesel and dual-fuel engines, control measures to date have been directed mainly at limiting NO_x emissions. The most effective NO_x control technique for diesel engines is fuel injection retard, achieving nominal NO_x reductions (at eight degrees of retard) of 40 percent. Maximum NO_x reductions of about 65 percent are possible with combined retard and air-to-fuel ratio change. Both retarded fuel injection, eight degrees, and air to fuel ratio change, five percent change, are also effective in reducing NO_x emissions from dual fuel engines, achieving nominal NO_x reductions of about 40 percent, and maximum NO_x reductions of about 70 percent.

Other NO_x control techniques exist but are not considered feasible alternatives because of excessive fuel penalties, capital cost, or maintenance or operational problems. These techniques include exhaust gas recirculation (EGR), combustion chamber modification, water injection, and catalytic reduction.

Emission factors for stationary large-base diesel and dual-fuel engines are presented in Table 3.3.4.1.

References for Section 3.3.4

1. Standards Support and Environmental Impact Statement Volume I -Stationary Internal Combustion Engines. EPA 450/2-78-125a. Office of Air Quality Planning and Standards, Research Triangle Park, NC. July 1979.

TABLE 3.3.4-1 Emission Factors for Stationary Large-Bore Diesel and Dual-Fuel Engines[a]

How Developed?

	Nitrogen Oxides (as NO_2)[b]	Carbon Monoxide	Hydrocarbons (as C)[c]	Sulfur Dioxide[d]	Particulate[e]
Diesel Engines					
lb/10^3hp-hr	24	6.4	0.7	7.0	NA
g/hp-hr	11	2.9	0.3	3.3	NA
g/kW-hr	14.7	3.9	0.4	4.4	NA
lb/10^3gal[f]	500	132	13.7	151	NA
kg/10^3 liter	60	15.8	1.6	18.1	NA
Dual Fuel Engines					
lb/10^3hp-hr	18	5.9	6.2		NA
g/hp-hr	8	2.7	2.8		NA
g/kW-hr	10.7	3.6	3.8		NA

VOC

Relate if not available

LOOKING AT DATA, VALUE OK, SEE NMHC, MNC SPLIT, COMMENTS

THIS ACTUALLY MAY BE MISLEADING

MAY BE LOW

OK

OK

MISSING

why three significant fig.

[a] Representative uncontrolled NO_x levels for each fuel are determined by weighting data from several manufacturers. Weighting is based on the percentage of total horsepower sold by each manufacturer during a five year period.

[b] These factors are for engines operated at rated load and speed.

[c] These factors represent total hydrocarbons. Nonmethane hydrocarbons are estimated to make up 5 to 10 percent of these totals on the average.

IF DATA IS AVAILABLE, A BREAKDOWN OF NONMETH. COMPOUNDS IS REQUIRED

WANT A BEST ESTIMATE, NOT A RANGE

[d] Based on an assumed sulfur content of 1 percent by weight for diesel fuel and 200 gr/10°SCF for pipeline quality natural gas. Dual-fuel SO_2 emissions based on 5 percent oil-firing and 95 percent gas-firing. Emissions should be adjusted based on fuel ratio.

WHAT EMISSIONS?

[e] Not available from existing data. WHY?

[f] These factors are calculated from the above factors assuming a heating value of 145,000 BTU/gallon oil and an average fuel consumption of 7000 BTU/hp-hr.

See pgs. 4-46 & 4-47

DRAFT EIO SAYS ALL NONMETHANE FOR DIESEL

Fig. 4-15(a)

EVEN DUAL FUEL NMHC EMISSIONS ARE 10-25% OF THC. (FIG 4-15(b))

ACUREX Corporation

Energy & Environmental Division

June 2, 1981

Bill Lamason (MD-13)
OAQPS/MDAD
U.S. Environmental Protection Agency
Research Triangle Park, NC 27711

Dear Bill:

Enclosed find the final draft of the AP-42 section on stationary large bore diesel and dual fuel engines including the latest revisions and format changes. Please relay any further comments you may have to either Jim MacQueen or myself.

Sincerely,

Jim MacQueen for

Larry R. Waterland
Project Manager

Enclosure

cc: Doug Bell (OAQPS/SDB, MD-13)

ACUREX CORPORATION: AEROTHERM GROUP, SOUTH/EAST REGIONAL OPERATIONS
AIRPORT ROAD AT LUMLEY ROAD, RTE. 1, BOX 423, MORRISVILLE, N.C. 27560 PHONE (919) 781-9704

Bill Hamason

3.3.4 Sta Lg Bore Diesel and Dual Fuel Engines

Comments on Draft / A. MacLucas

1. I propose that the section text in 3.3.4.1, General provide specific information that says what size these engines are, rated load capacity and fuel use under rated load OR whatever other way is used to indicate their size.

2. How valid is the assumed 1.0 weight percent sulfur in diesel fuel for these engines? Sounds high.

3. Isn't there enough information on the emissions from the four engine types to provide emission factors for each type or aren't the variations statistically significant?

F.Y.I → Jim FRANK ARCH

RETURN TO BILL

SECOND DRAFT AP-42

DRAFT

3.3.4 Stationary Large-Bore Diesel and Dual-Fuel Engines

3.3.4.1 General[1] - The primary high usage domestic application of large-bore (i.e., greater than 560 cubic inch displacement per cylinder, CID/CYL) diesel engines is oil and gas exploration and production. These engines, in groups of three to five, supply mechanical power to operate the drilling (rotary table), mud pumping, and hoisting equipment. In other instances, these engines may operate pumps or generator sets for auxiliary power. A secondary high usage application of large-bore diesels is for electrical generation, both base and standby service. Other various small usage applications include irrigation, hoisting, and nuclear power plant emergency cooling water pump operation.

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Other NO_x control techniques exist but are not usually ~~considered feasible~~ viable ← poor term for technical context and is ambiguous. alternatives because of excessive fuel penalties, capital cost, or maintenance or operational problems. These techniques include exhaust gas recirculation (EGR), combustion chamber modification, water injection, and catalytic reduction.

Emission factors for stationary large-bore diesel and dual-fuel engines are presented in Table 3.3.4.1.

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1. Standards Support and Environmental Impact Statement Volume I - Stationary Internal Combustion Engines. EPA 450/2-78-125a. Office of Air Quality Planning and Standards, Research Triangle Park, NC. July 1979.

TABLE 3.3.4-1 Emission Factors for Stationary Large-Bore Diesel and Dual-Fuel Engines[a]

Rating?

	Nitrogen Oxides (as NO_2)[b]	Carbon Monoxide	VOC (as C)[c] Methane	VOC (as C)[c] Nonmethane	Sulfur Dioxide[d]
Diesel Engines	24	6.4	0.07	0.63	7.0
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g/hp-hr	15	3.9	0.04	0.39	4.3
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g/l[e]	—	—	—	—	—
Dual Fuel Engines					
lb/10^3hp-hr	18	5.9	4.7	1.5	0.70
g/hp-hr	8.0	2.7	2.1	0.7	0.32
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[a]Representative uncontrolled levels for each fuel are determined by weighting data from several manufacturers. Weighting is based on the percentage of total horsepower sold by each manufacturer during a five year period.

[b]These factors are for engines operated at rated load and speed.

[c]Nonmethane VOC accounts for 90 percent of total VOC from diesel engines but only 25 percent of total VOC emissions from dual fuel engines.

[d]Based on an assumed sulfur content of 1 percent by weight for diesel fuel and 0.46 g/scm (0.20 gr/scf) for pipeline quality natural gas. Dual-fuel SO_2 emissions based on 5 percent oil-firing and 95 percent gas-firing. Emissions should be adjusted based on fuel ratio.

[e]These factors are calculated from the above factors assuming a heating value of 40 MJ/l (145,000 Btu/gal) for oil, 41 MJ/scm (1100 Btu/scf) for natural gas, and an average fuel consumption of 9.9 MJ/kW-hr (7000 Btu/hp-hr).

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Uncontrolled emission factors for NO_x, CO, and VOC (both total and nonmethane) for stationary large-bore diesel and dual-fuel engines were derived from engine manufacturer-supplied data. These data exhibited some variability in emissions from engines of different designs. To account for this variability, a sales-weighted average approach was used. The procedure adopted was to compute a weighted average uncontrolled emission level for engines in the diesel and dual-fuel categories. The weighted levels are based on sales of engine horsepower during the past 5 years for domestic applications. Sales of horsepower to standby services were excluded from the computation.

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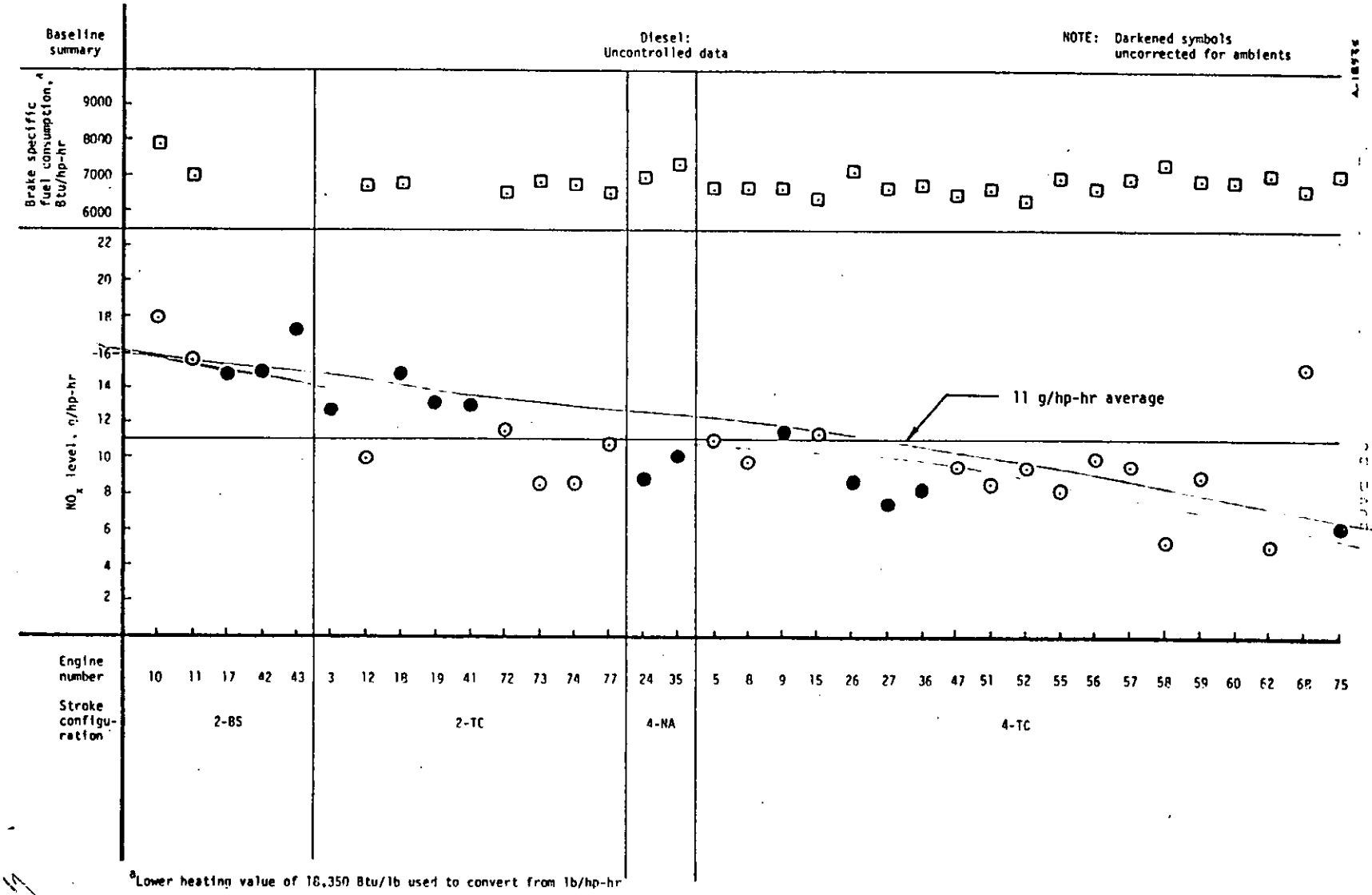


[a]Lower heating value of 18,350 Btu/lb used to convert from lb/hp-hr

Figure 1. Uncontrolled NO_x emissions from diesel engines.

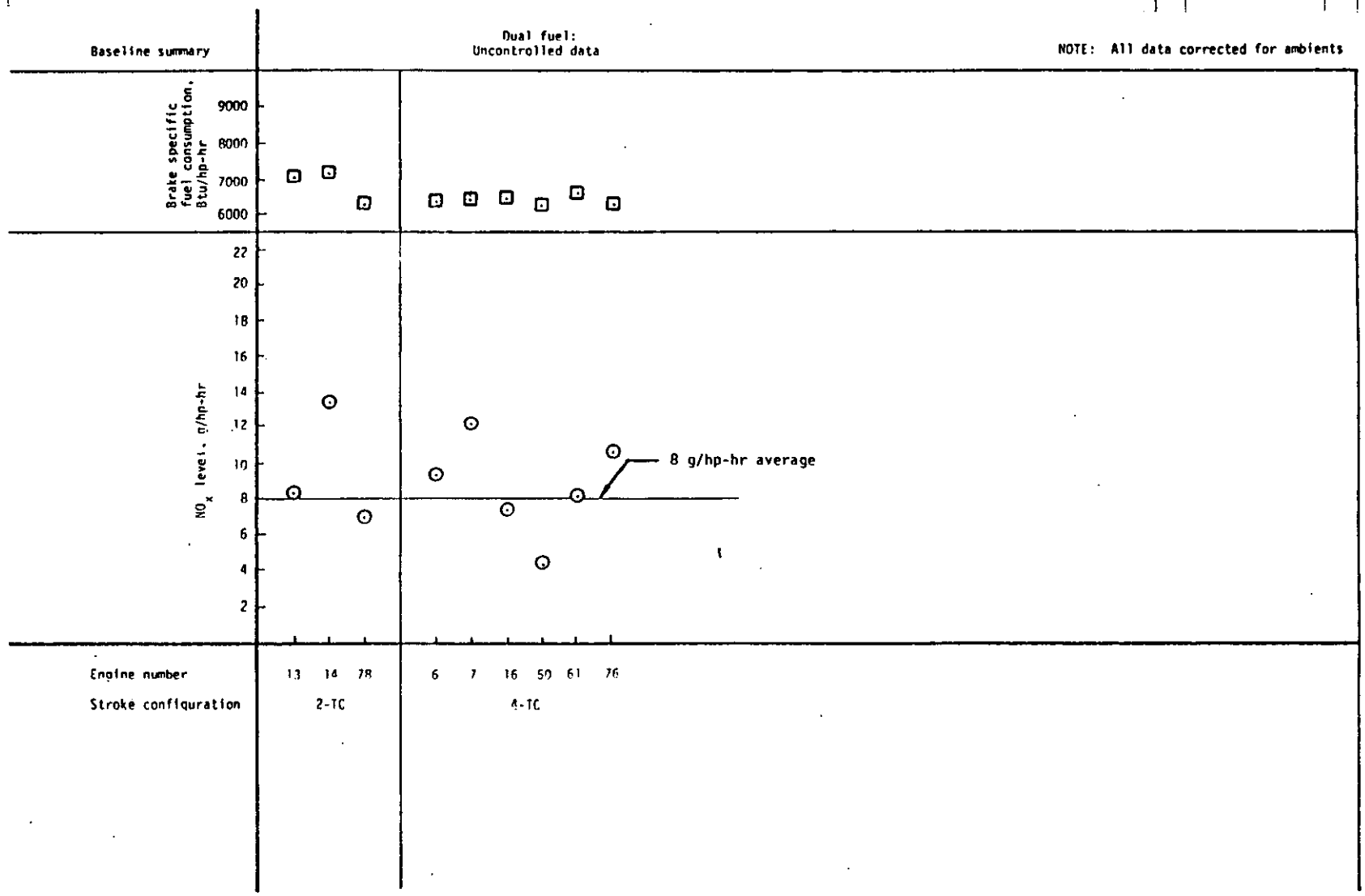


Figure 2. Uncontrolled NO_x emissions from dual fuel engines.

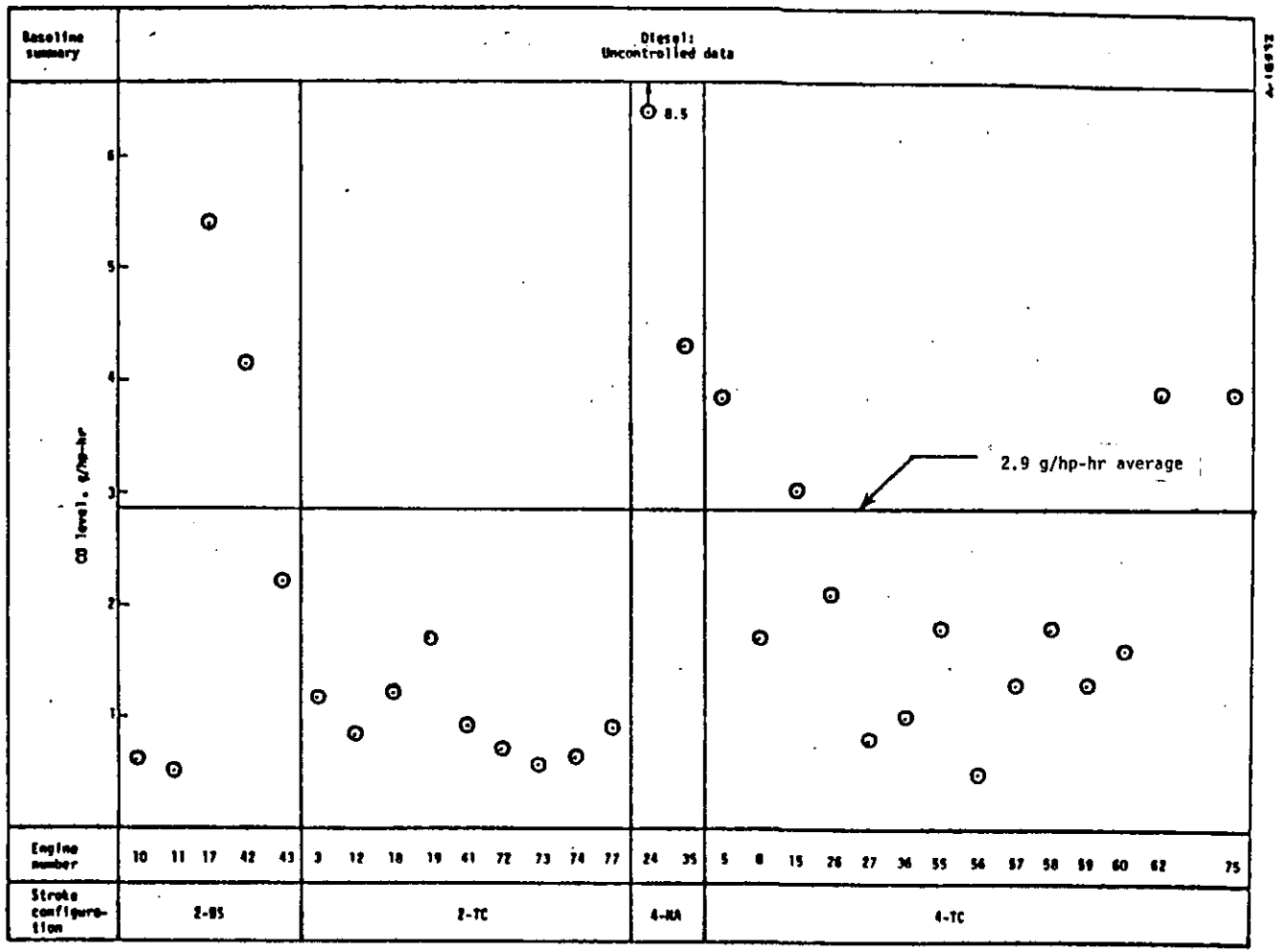


Figure 3. Uncontrolled CO emissions from diesel engines.

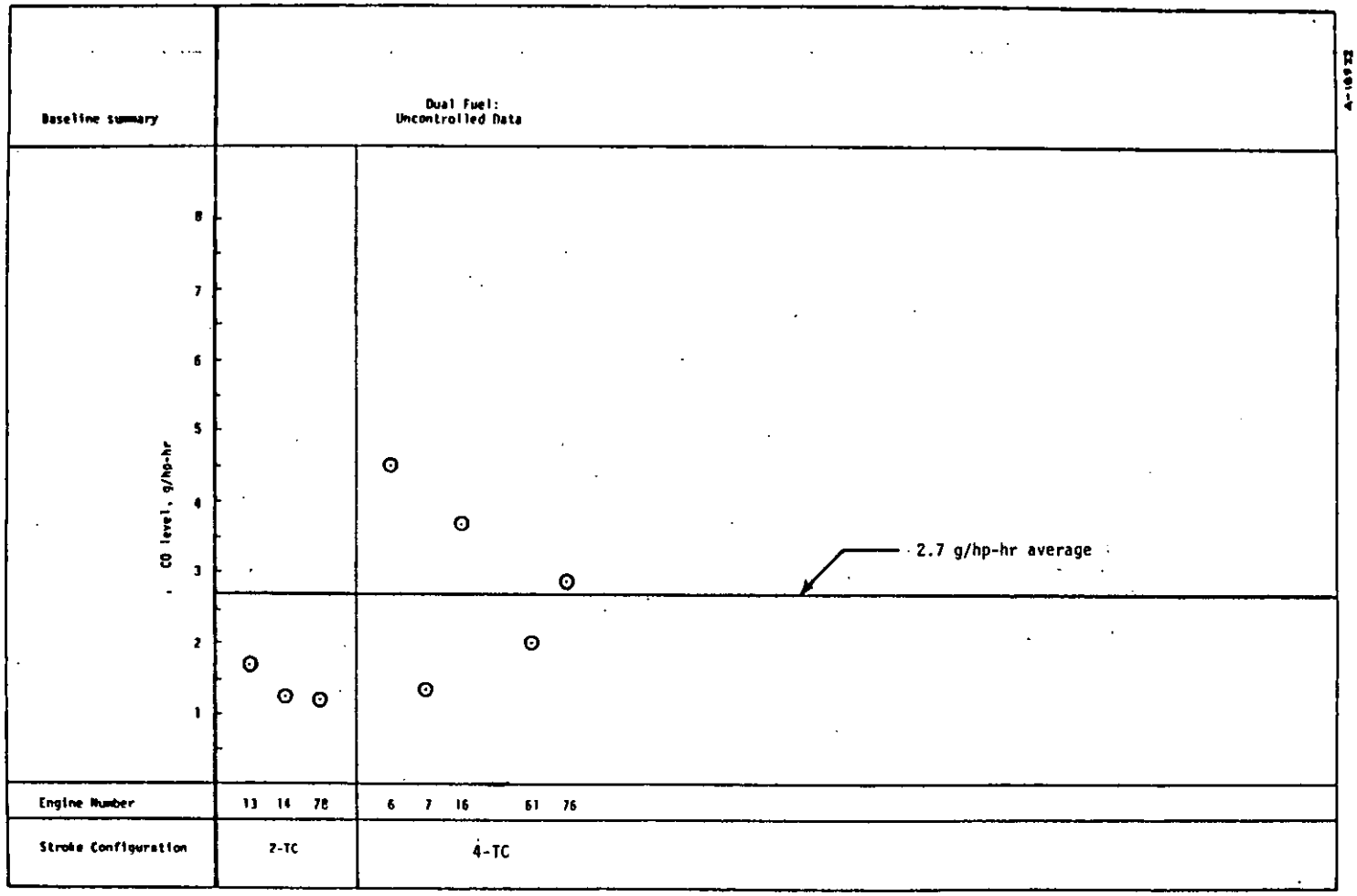
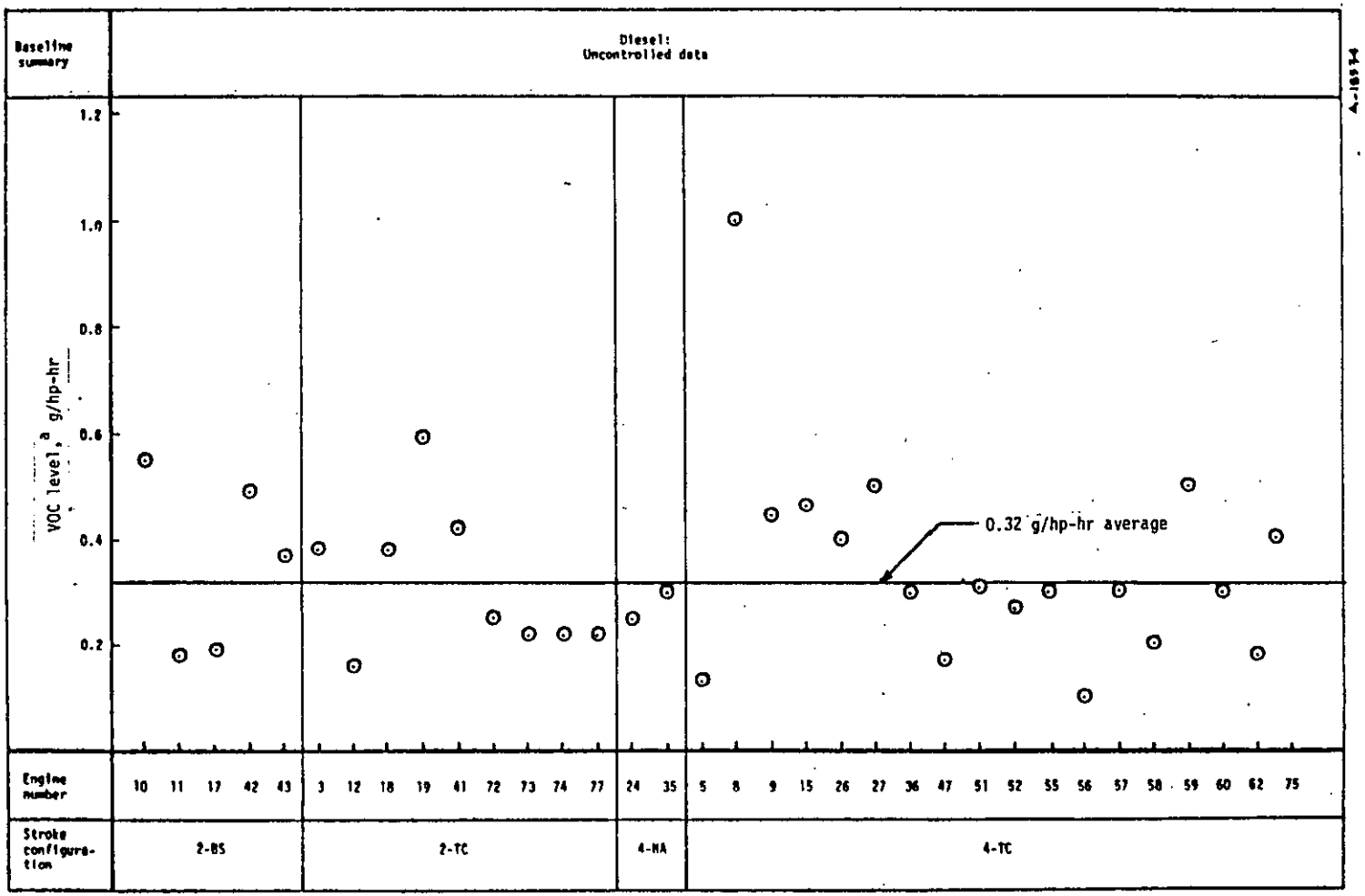


Figure 4. Uncontrolled CO emissions from dual fuel engines.



[a]VOC assumed to be 90 percent nonmethane

Figure 5. Uncontrolled VOC emissions from diesel engines.

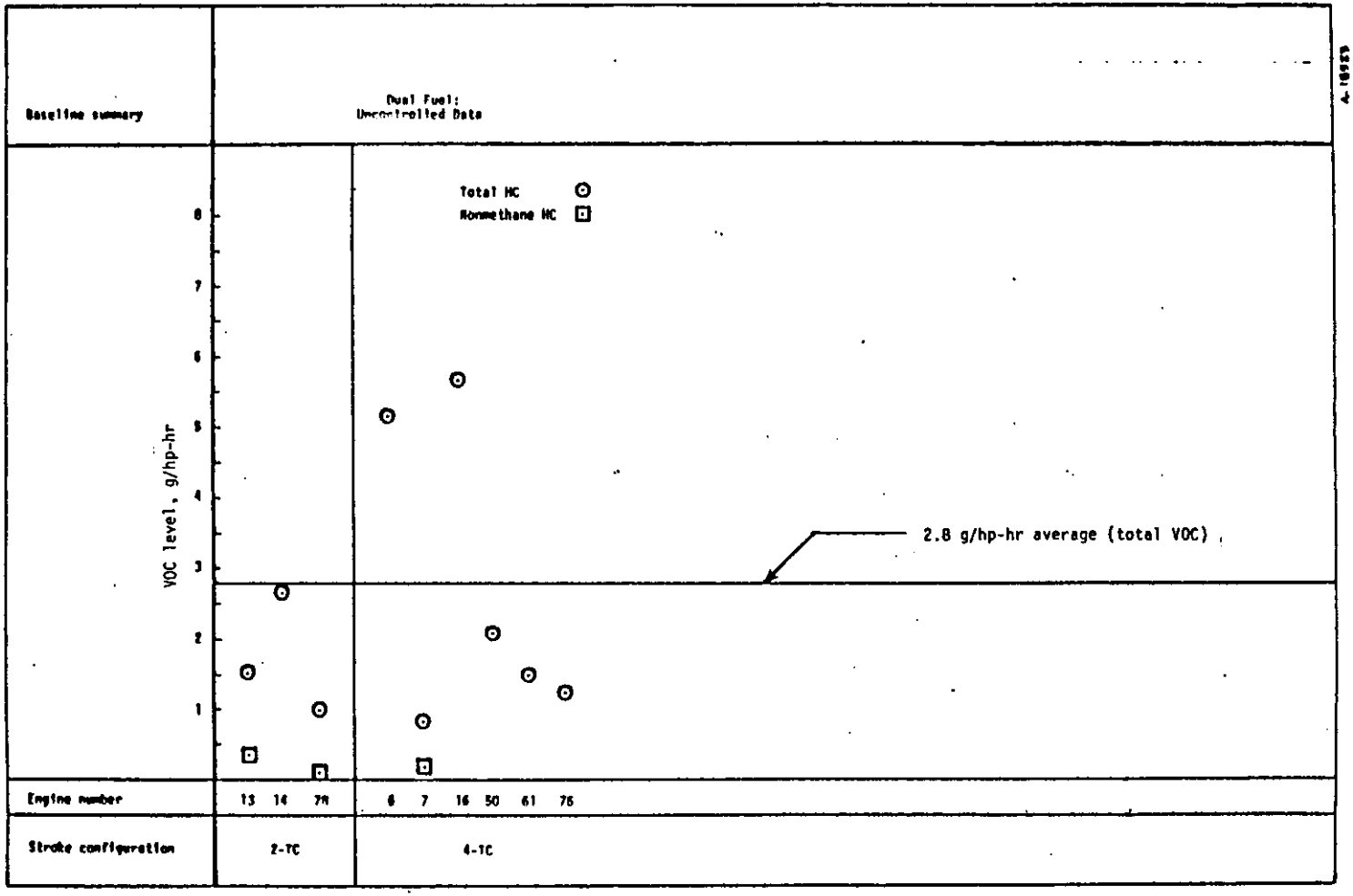


Figure 6. Uncontrolled VOC emissions from dual fuel engines.

TABLE 1. Sales-Weighted Average Emission Factors for Stationary Large-Bore Diesel and Dual-Fuel Engines (g/hp-hr)

Fuel	NO_x (as NO_2)[a]	CO	VOC (as C)[b] Methane	VOC (as C)[b] Nonmethane	SO_2[c]
Diesel	11	2.9	0.03	0.29	3.2
Dual-Fuel	8.0	2.7	2.1	0.7	0.32

[a]At rated load and speed.

[b]Nonmethane VOC accounts for 90 percent of total VOC from diesel engines and 25 percent of total VOC from dual-fuel engines.

[c]Based on: sulfur content of 1 percent by weight for diesel fuel, 0.46 g/scm (0.20 gr/scf) for natural gas; heating value of 40 MJ/l (145,000 Btu/gal) for diesel fuel, 41 MJ/scm (1100 Btu/scf) for natural gas; average fuel consumption of 7.4 MJ/hp-hr (7000 Btu/hp-hr); and dual-fuel firing 5 percent diesel and 95 percent natural gas.

Table 1 also shows SO_2 emission factors. SO_2 emissions are solely a function of fuel sulfur content. The emission factors in Table 1 assume the sulfur content of diesel fuel is one percent by weight, and of natural gas is 0.46 g/scm (0.20 gr/scf). The heating value of diesel is assumed to be 40 MJ/l (145,000 Btu/gal), and of natural gas to be 41 MJ/scm (1100 Btu/scf). Average fuel consumption is assumed to be 7.4 MJ/hp-hr (7000 Btu/hp-hr), and dual-fuel engines are assumed to burn 5 percent diesel and 95 percent natural gas on a heat input basis.

Restate
reference (s)

ACUREX Corporation

Energy & Environmental Division

April 29, 1981

Bill Lamason (MD-13)
OAQPS/MDAD
U.S. EPA
Research Triangle Park, NC 27711

Dear Bill:

Enclosed find the final draft of the AP-42 section on stationary large-bore diesel and dual fuel engines along with a draft of the background support document justifying the emission factors noted. Please relay any further comments you have either to Jim Laughlin of HMM Associates (782-0824), or to Henry Modetz of Acurex.

Sincerely,

Andrew J. Murphy for

Larry R. Waterland
Project Manager

Encl.

cc: Doug Bell (OAQPS/SDB, MD-13)

ACUREX CORPORATION: AEROTHERM GROUP, SOUTH/EAST REGIONAL OPERATIONS
AIRPORT ROAD AT LUMLEY ROAD, RTE. 1, BOX 423, MORRISVILLE, N.C. 27560 PHONE (919) 781-9704

BACKGROUND INFORMATION FOR DEFINING EMISSION FACTORS FOR STATIONARY LARGE-BORE DIESEL AND DUAL-FUEL ENGINES

Uncontrolled emission factors for NO_x, CO, and VOC (both total and nonmethane) for stationary large-bore diesel and dual-fuel engines were derived from engine manufacturer-supplied data. These data exhibited some variability in emissions from engines of different designs. To account for this variability, a sales-weighted average approach was used. The procedure adopted was to compute a weighted average uncontrolled emission level for engines in the diesel and dual-fuel categories. The weighted levels are based on sales of engine horsepower during the past 5 years for domestic applications. Sales of horsepower to standby services were excluded from the computation.

Figures 1 through 6 show uncontrolled emission levels for NO_x, CO, and VOC (with nonmethane VOC noted where measured), taken from engine manufacturer's data. On each figure the data are differentiated by engine design type. Engine types noted are two-stroke, blower scavenged (2-BS), two- and four-stroke turbocharged (2-TC, 4-TC), and four-stroke naturally aspriated (4-NA). NO_x emission data were corrected for ambient temperature and humidity where sufficient data existed.

Also noted in the figures are the sales-weighted average emissions factors calculated. These emission factors for NO_x, CO, and VOC are summarized in Table 1. Note that the sales-weighted average VOC emission factors shown in Figures 5 and 6 are for total VOC emissions. These are split into methane and nonmethane VOC in Table 1 by noting that 90 percent of the VOC emitted from diesel engines and 25 percent of the VOC from dual-fuel engines is nonmethane.

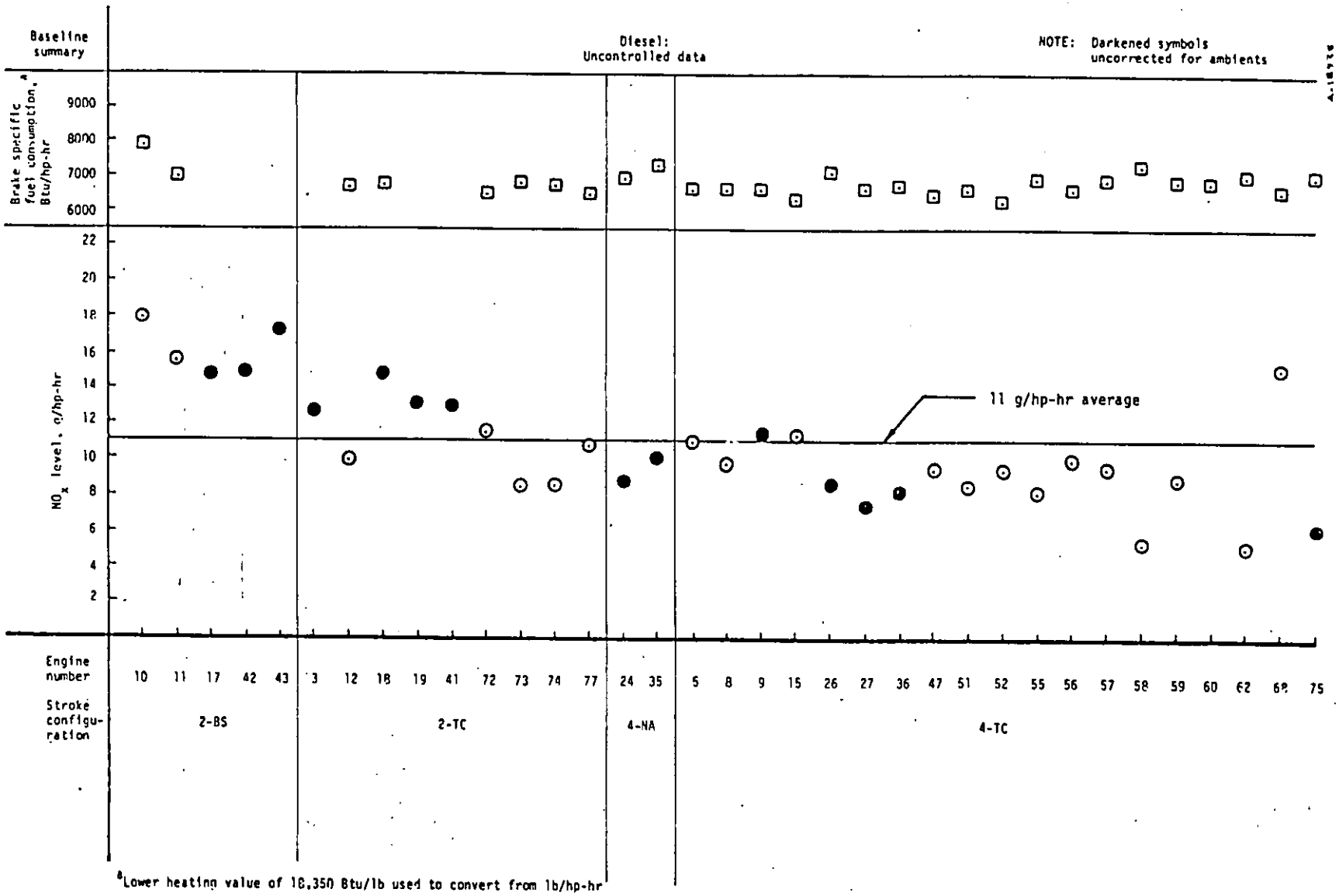


Figure 1. Uncontrolled NO_x emissions from diesel engines.

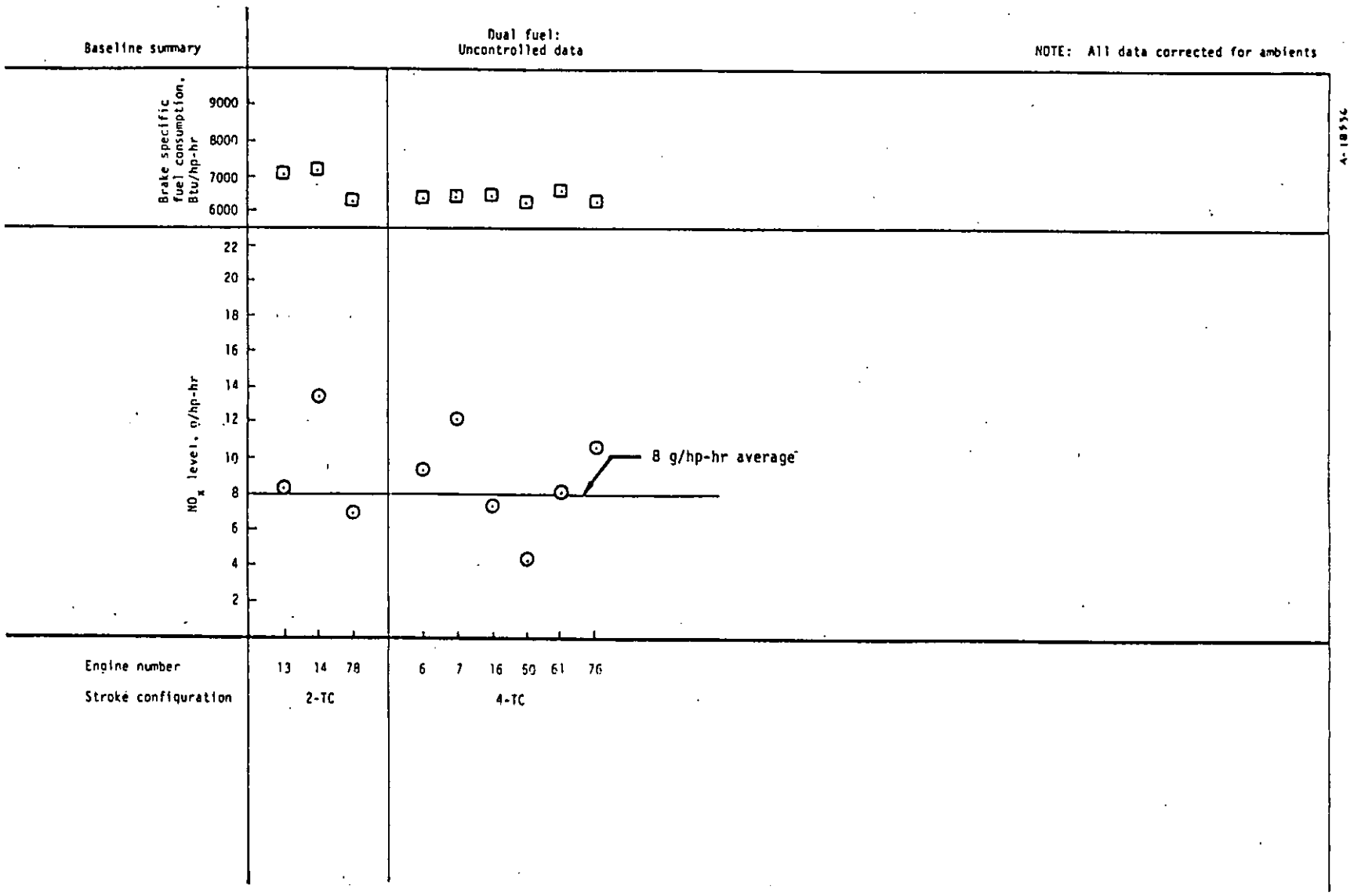


Figure 2. Uncontrolled NO_x emissions from dual fuel engines.

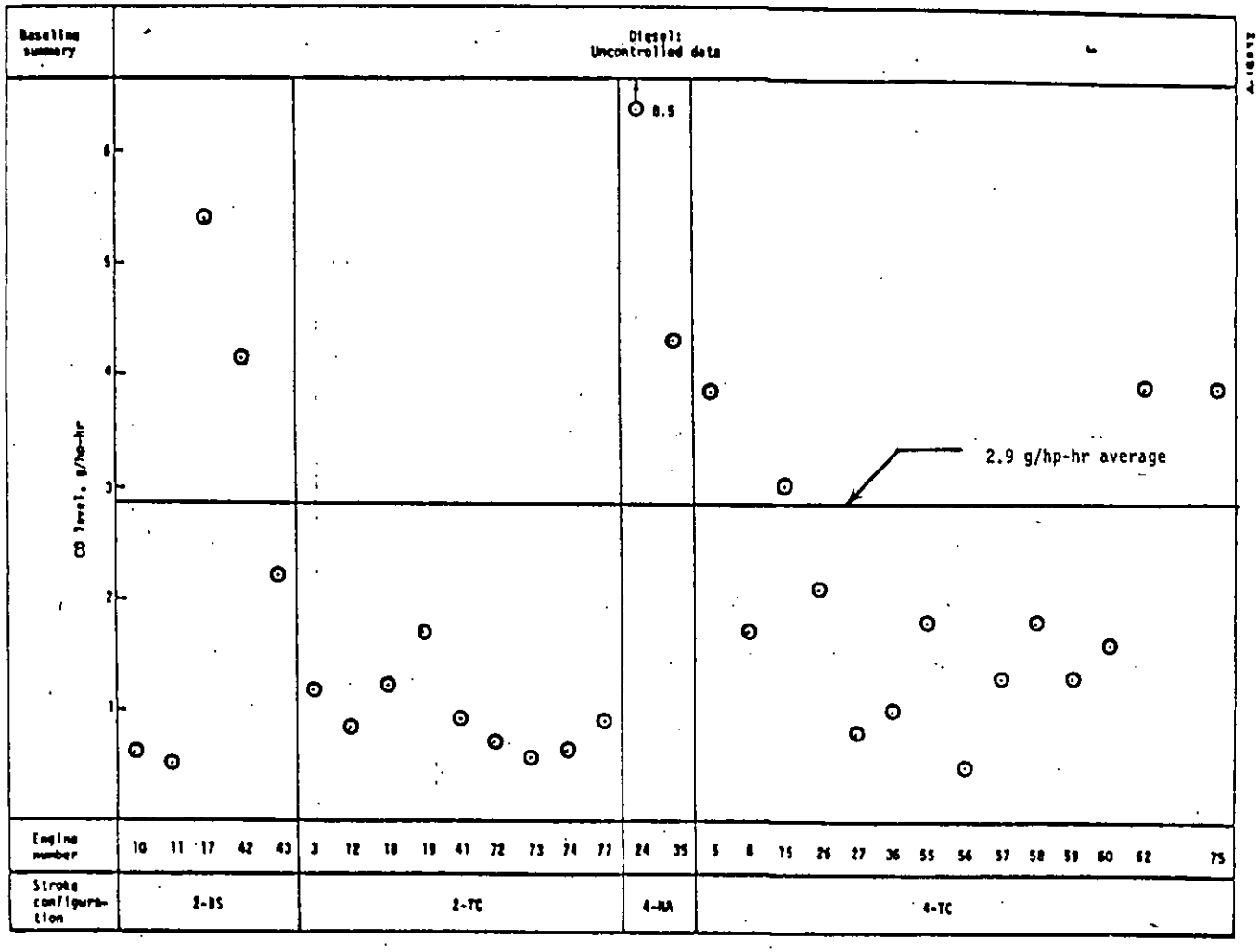


Figure 3. Uncontrolled CO emissions from diesel engines.

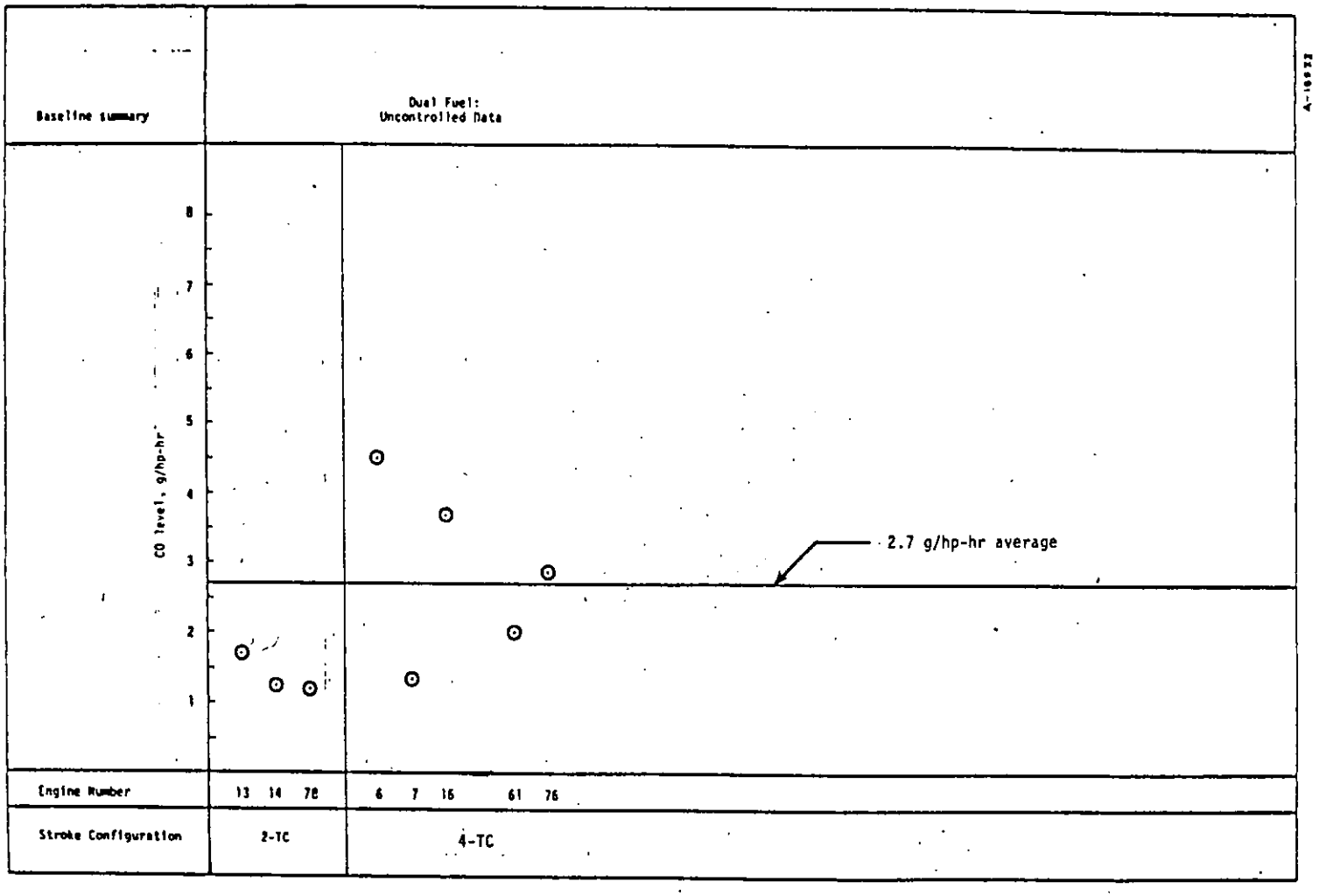
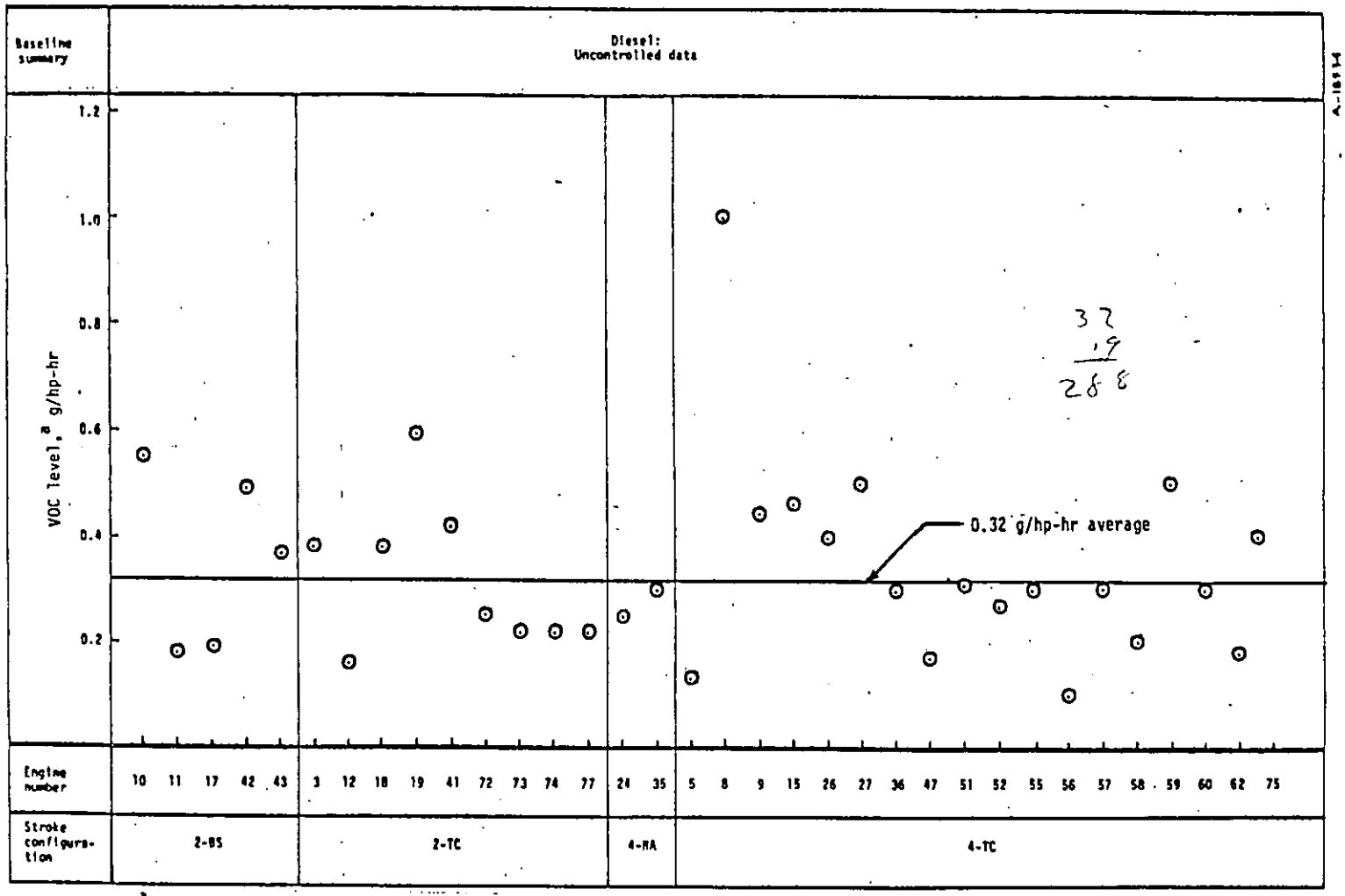


Figure 4. Uncontrolled CO emissions from dual fuel engines.



[a]VOC assumed to be 90 percent nonmethane

Figure 5. Uncontrolled VOC emissions from diesel engines.

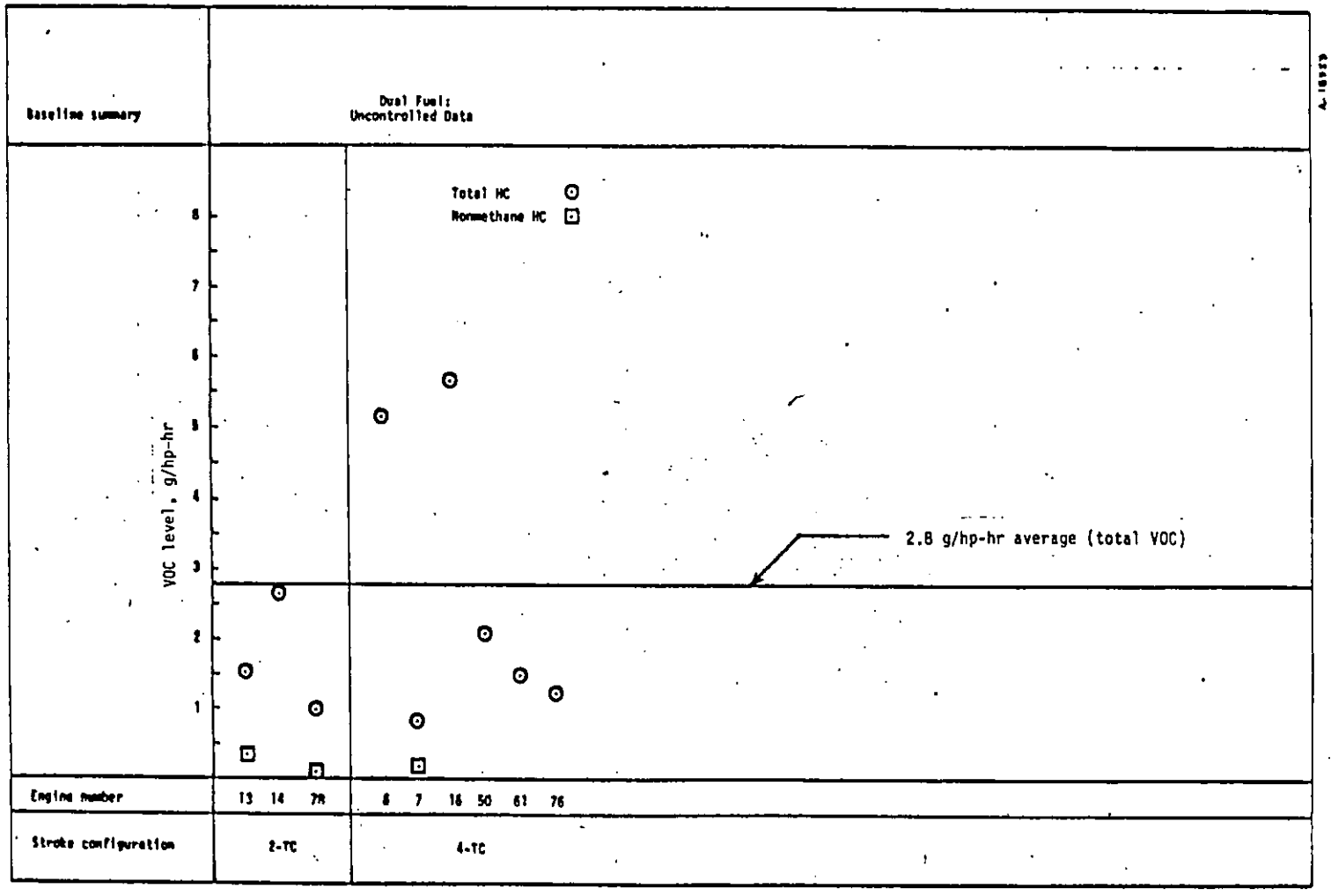


Figure 6. Uncontrolled VOC emissions from dual fuel engines.

TABLE 1. Sales-Weighted Average Emission Factors for Stationary Large-Bore Diesel and Dual-Fuel Engines (g/hp-hr)

Fuel	NO_x (as NO_2)[a]	CO	VOC (as CH_4)[b] Methane	VOC (as CH_4)[b] Nonmethane	SO_2[c]
Diesel	11	2.9	0.03	0.29	3.2
Dual-Fuel	8.0	2.7	2.1	0.7	0.32

[a]At rated load and speed.

[b]Nonmethane VOC accounts for 90 percent of total VOC from diesel engines and 25 percent of total VOC from dual-fuel engines.

[c]Based on: sulfur content of 1 percent by weight for diesel fuel, 0.46 g/scm (0.20 gr/scf) for natural gas; heating value of 40 MJ/l (145,000 Btu/gal) for diesel fuel, 41 MJ/scm (1100 Btu/scf) for natural gas; average fuel consumption of 7.4 MJ/hp-hr (7000 Btu/hp-hr); and dual-fuel firing 5 percent diesel and 95 percent natural gas.

Table 1 also shows SO_2 emission factors. SO_2 emissions are solely a function of fuel sulfur content. The emission factors in Table 1 assume the sulfur content of diesel fuel is one percent by weight, and of natural gas is 0.46 g/scm (0.20 gr/scf). The heating value of diesel is assumed to be 40 MJ/l (145,000 Btu/gal), and of natural gas to be 41 MJ/scm (1100 Btu/scf). Average fuel consumption is assumed to be 7.4 MJ/hp-hr (7000 Btu/hp-hr), and dual-fuel engines are assumed to burn 5 percent diesel and 95 percent natural gas on a heat input basis.

3.3.1 Stationary Diesel Engines for Electrical Utility Power Plants

3.3.1.1 General - Stationary diesel engines find application in the electric utility industry, in natural gas transmission, and in various process industries. Diesel engines used in the electric power plants usually operate under constant and continuous conditions. There is, however, a smaller number of diesels for peaking or standby power service. The liquid fuel diesels generally use a light distillate oil, such as No. 2; the gas diesels, or dual-fuel diesels, use a combination of natural gas (between 80 to 95 percent of the heat input) and liquid fuel which is used to initiate ignition.

3.3.1.2 Emissions - Emission data on stationary engines for electrical utility power plants have been gathered and analyzed in references 1 and 2. The information provided on emissions from diesel engines shows a considerable range in terms of absolute values, and varies in terms in which the emissions are expressed. In this section the data is reorganized and converted to uniform units. The emission factors given indicate a representative value based on a series of assumptions on the type of engine, on the average power capacity per engine (average from a sample population of 446 engines), and on the relationship between unit power capacity and emission rates (a linear relationship is utilized). The emission rates refer to four-cycle engines for both the liquid and the gas diesels; more data is required in order to obtain the emissions as functions of the charging mechanism and the number of cycles per engine.

In continuous power installations, diesel engines usually operate at 80 to 90 percent of their rated power for about 6,000 to 8,000 hours per year. In the relatively few peaking installations, the unit operates for several hours per day near full load. The standby units generally run for 1 to 3 hours per week. The emission factors provided in this section refer to constant conditions. Table 3.3.1-1 lists the emission factors for diesel engines. The average power capacity per engine is assumed to be 1678 Bhp and 2585 Bhp, for oil and gas diesels respectively. The gas low-heat value utilized for conversion purposes is: Gas - LHV = 950 Btu/SCF; the heat value for distillate oil No. 2 is 141,000 Btu/gal. Finally we assume an 80 to 20 percent distribution of dual fuel diesels to liquid diesels.

The emission factors provided in Table 3.3.1-1 should be used with caution since they are based on the indicated average power capacity per unit engine.

TABLE 3.3.1-1. EMISSION FACTORS FOR ELECTRIC UTILITY DIESELS

	Emission Factors (lbm/hr) at Constant Conditions		
Pollutant	Entire Population	Gas Diesel	Oil Diesel
NO_x	43.44	46.74	30.22
CO	10.55	11.40	7.14
HC	14.24	17.67	0.51

	Composite Factors, Fuel Basis	
Pollutant	(lbm/10^6 ft^3 gas)*	(lbm/10^3 gal oil)**
NO_x	2,850	338
CO	703	81
HC	1,045	5.5

* Emissions for dual fuel diesels (95 percent natural gas).

** Emissions for liquid fuel diesels.

References for Section 3.3.1

1. McGowin, Charles R. Stationary Internal Combustion Engines in the United States. Shell Development Co. Prepared for the Environmental Protection Agency - Technology Series. April 1973.

2. Roessler, W.U., A. Muraszew, and R.D. Kopa. Assessment of the Applicability fo Automotive Emission Control Technology to Stationary Engines. The Aerospace Corporation, Urban Programs Division. Prepared for the Environmental Protection Agency - Technology Series. July 1974.

3.3.4
BILL

Catalyst Tests Completed on Large-Bore Stationary I.C. Engines

A. D. Little, Inc. (EPA Contract 68-02-2664) and subcontractors, Cooper Energy Services and Fairbanks-Morse, have recently completed tests on exhaust catalyst NO_x control technology for both natural gas and diesel engines. The following conclusions were drawn from the results of the experimental program:

1. Under ideal conditions (adequate space velocity and control of exhaust temperature, NH_3 level, and particulates), 97-98 percent NO_x reduction could be obtained with three different base metal catalysts.

2. NO_x reduction of diesel exhaust was comparable to gas engine exhaust, with small amounts of accumulated soot enhancing the catalyst performance at higher temperatures.

3. Diesel soot must, however, be reduced to small amounts for the exhaust to be treated by NH_3 reduction. Accumulation of substantial soot layers impairs catalyst performance.

4. Different catalysts exhibited space velocity thresholds for operation.

5. NH_3/NO_x ratio should be controlled between 1.0 and 1.1 for best results. Higher values give increased NH_3 emissions and lower values leave NO_x reduction incomplete.

6. Extended runs on two catalysts and two engines indicate that realistic long-term catalyst performance will be in the 75-85 percent NO_x reduction range.

7. A special dispersive infrared analyzer for NH_3 was developed for this study and offers promise as a real time-measuring device for feedback control of NH_3 addition.

(J.H. Wasser, FTS: 629-2476)

ACUREX Corporation

Energy & Environmental Division

April 29, 1981

Bill Lamason (MD-13)
OAQPS/MDAD
U.S. EPA
Research Triangle Park, NC 27711

Dear Bill:

Enclosed find the final draft of the AP-42 section on stationary large-bore diesel and dual fuel engines along with a draft of the background support document justifying the emission factors noted. Please relay any further comments you have either to Jim Laughlin of HMM Associates (782-0824), or to Henry Modetz of Acurex.

Sincerely,

Andrew J. Murphy for

Larry R. Waterland
Project Manager

Encl.

cc: Doug Bell (OAQPS/SDB, MD-13)

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3.3.4 STATIONARY LARGE-BORE DIESEL AND DUAL-FUEL ENGINES

3.3.4.1 General[1]

The primary high usage domestic application of large-bore (i.e., greater than 560 cubic inch displacement per cylinder, CID/CYL) diesel engines is oil and gas exploration and production. These engines, in groups of three to five, supply mechanical power to operate the drilling (rotary table), mud pumping, and hoisting equipment. In other instances, these engines may operate pumps or generator sets for auxilliary power. A secondary high usage application of large-bore diesels is for electrical generation, both base and standby service. Other various small usage applications include irrigation, hoisting, and nuclear power plant emergency cooling water pump operation.

Dual-fuel engines were developed to take advantage of both compression ignition performance and inexpensive natural gas. These engines require a minimum of 5 to 6 percent diesel fuel to ignite the natural gas. Dual-fuel large-bore engines (greater than 560 CID/CYL) have been used almost exclusively for prime electric power generation.

3.3.4.2 Emissions and Controls[1]

The primary pollutant of concern from large-bore diesel and dual-fuel engines is NO_x, which readily forms in the high temperature, pressure, and excess air environment found in these engines. Lesser amounts of carbon monoxide and hydrocarbons are emitted. Sulfur dioxide emissions are proportional to the sulfur content of the fuel and will usually be quite low because of the negligible sulfur content of diesel fuels and natural gas.

The major variables affecting NO_x emissions from diesel engines include ignition timing, manifold air temperature, engine speed, engine load, and ambient humidity. In general, No_x emissions decrease with increasing humidity.

Because NO_x is the primary pollutant of significance emitted from diesel and dual-fuel engines, control measures to date have been directed mainly at limiting NO_x emissions. The most effective NO_x control technique for diesel engines is fuel injection retard, achieving nominal NO_x reductions (at eight degrees of retard) of 40 percent. Maximum NO_x reductions of about 65 percent are possible with combined retard and air-to-fuel ratio change. Both retarded fuel injection, eight degrees, and air-to-fuel ratio change, five percent change, are also effective in reducing NO_x emissions from dual-fuel engines, achieving nominal NO_x reductions of about 40 percent, and maximum NO_x reductions of about 70 percent.

Other NO_x control techniques exist but are not considered feasible alternatives because of excessive fuel penalties, capital cost, or maintenance or operational problems. These techniques include exhaust gas recirculation (EGR), combustion chamber modification, water injection, and catalytic reduction.

Emission factors for stationary large-bore diesel and dual-fuel engines are presented in Table 3.3.4.1.

Reference for Section 3.3.4

1. Standards Support and Environmental Impact Statement Volume I - Stationary Internal Combustion Engines, EPA 450/2-78-125a, Office of Air Quality Planning and Standards, Research Triangle Park, NC, July 1979.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
WASHINGTON, D.C. 20460
OFFICE OF
AIR AND WASTE MANAGEMENT

TABLE 3.3.4-1. Emission Factors for Stationary Large-Bore Diesel and Dual-Fuel Engines[a]

Emission Factor Rating: C

	Nitrogen Oxides (as NO_2)[b]	Carbon Monoxide	VOC (as CH_4)[c] Methane	VOC (as CH_4)[c] Nonmethane	Sulfur Dioxide[d]
Diesel Engines					
$lb/10^3$hp-h	24	6.4	0.07	0.63	7.0
g/hp-h	11	2.9	0.03	0.29	3.2
g/kW-h	15	3.9	0.04	0.39	4.3
$lb/10^3$gal[e]	500	130	1	13	150
g/l[e]	60	16	0.2	1.6	18
Dual Fuel Engines					
$lb/10^3$hp-h	18	5.9	4.7	1.5	0.70
g/hp-h	8.0	2.7	2.1	0.7	0.32
g/kW-h	11	3.6	2.9	0.9	0.43

[a]Representative uncontrolled levels for each fuel are determined by weighting data from several manufacturers. Weighting is based on the percentage of total horsepower sold by each manufacturer during a five year period.

[b]These factors are for engines operated at rated load and speed.

[c]Nonmethane VOC accounts for 90 percent of total VOC from diesel engines but only 25 percent of total VOC emissions from dual fuel engines.

[d]Based on an assumed sulfur content of 1 percent by weight for diesel fuel and 0.46 g/scm (0.20 gr/scf) for pipeline quality natural gas. Dual-fuel SO_2 emissions based on 5 percent oil-firing and 95 percent gas-firing. Emissions should be adjusted based on fuel ratio.

[e]These factors are calculated from the above factors assuming a heating value of 40 MJ/l (145,000 Btu/gal) for oil, 41 MJ/scm (1100 Btu/scf) for natural gas, and an average fuel consumption of 9.9 MJ/kW-h (7000 BTU/hp-h).