PROCEEDINGS OF THE EPA/INDUSTRY QUALITY CONTROL SYMPOSIUM

INTRA-LABORATORY TEST SITE/EQUIPMENT QUALITY CONTROL TECHNIQUES

October 5, 1977

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October 5, 1977
9:00 A.M. - 4:00 P.M.

HELD AT:
Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, Michigan 48103

Symposium Chairman:
Frank E. Johnson
Emission Development Testing
Chrysler Corporation
Detroit, Michigan 48288

SUMMARY REPORT

EPA/INDUSTRY QUALITY CONTROL SYMPOSIUM

INTRA-LABORATORY TEST SITE/EQUIPMENT

QUALITY CONTROL TECHNIQUES

INTRODUCTION:

This report summarizes the proceedings, information, discussions and presentations made at the Fourth Quality Control Symposium held at the Environmental Protection Agency Laboratory, Ann Arbor, Michigan, on October 5, 1977.

As in the previous meetings, this symposium was a joint EPA/Automotive Industry effort to discuss the Quality Control techniques used to assure that a test facility is producing valid emissions data. Approximately 53 persons attended the symposium and are listed in Appendix 1.

The symposium was conducted in the manner of the previous meetings in that informal comments and presentations were encouraged. Because of this spontaneity, it is difficult to record a synopsis that flows with continuity.

The viewgraphs used in the presentations and additional information are contained in the appendices.

SYNOPSIS OF SYMPOSIUM:

The discussion of the presentations will follow the general outline of the symposium. Agenda Items I, II, and III have been combined because of their similarities.

Ford

Bruce Gardner, of Ford, presented a summary of quality control checks performed on the test cell equipment. The majority of Ford CVS systems are the venturi type. A list outlining the actual quality checks, the techniques, frequencies, and limits, is shown in Appendix 2.

Chrysler

Frank Johnson, of Chrysler, presented the quality control checks performed on the test cell equipment. The Chrysler facilities are connected to an on-line computer system which contains the analyzer calibration data and has analyzer range sensing capability.

Chrysler - Carbon Dioxide-Water Interference

A check list (Appendix 3) used by the Highland Park test cell operators each shift was discussed. The Chrysler carbon monoxide analyzers are equipped with pressurized carbon dioxide filter cells and optical filters. Therefore, the response to moist carbon dioxide is checked each shift. The mechanism for performing this test is built into the bag analyzer benches.

Analyzers are spanned at the beginning of each shift on the most sensitive range and are then checked on the two higher ranges; allowable deviations are ± 2% of the full scale range-to-range. Analyzer ranges that are switched during a test are spanned and zeroed. Chrysler believes in a mid-span check when calibrating so that each time an anlyzer is spanned, a mid-span check is made. Unadjusted mid span readings must be ± 1 recorder division. Typical analyzer ranges at the Chrysler Chelsea Proving Grounds are:

HYDROCARBON (ppm Propane)	CO (ppm)	% CO_2	NOx (ppm)
0-250	0-2000	0-4.0%	0-250
0-100	0-500	0-2.5	0-100
0-25	0-100	0-1.0	0-25

Chrysler - NOx Converter Efficiency

The NOx converter efficiency is checked weekly with a minimum acceptable efficiency of 90%, preferably 95% or better. If the efficiency is less than 95%, corrective action is taken.

Chrysler - Cell-to-Cell Correlation

On a weekly basis, at the Proving Grounds, a calibration gas standard of approximately 20-50% of the most commonly used range of the analyzers is analyzed at all test sites. The analyzers are spanned with the daily working gases. A deviation of ± 1 recorder division from the master curve is cause for immediate action; a deviation of ± .5 divisions initiates an investigation.

At the Highland Park facility, a gas blending station has been installed and connected to the central calibration system (Appendix 3). The blended gas is available to the cell operator at any time for a check of the analyzers. The system blends two cylinders in a ratio of approximately 20% Cylinder A to 80% Cylinder B. A system has been incorporated in the bag analyzer benches (Appendix 3) so that the blended gas can be read directly or the blended gas can be put in the CVS bags and read from the bags. This enables the operator to:

1. Check the bag analyzer curves.

2. Check the integrity of the CVS bags.

3. Check the bag analyzer sample system.

4. Check the adequacy of the bag evacuation and purge system.

5. Check NOx converter efficiency.

This system was in a trial status at the present time but a sample of the data generated was discussed (Appendix).

Chrysler uses the Heath PDP Constant Volume Sampler with the primary calibration performed using a Meriam Laminar Flow Element. A typical calibration was shown (Appendix).

The Constant Volume Samplers sample integrity is checked daily using a Critical Flow Orifice and propane gas. Typical data are shown (Appendix). If the percent error is greater than ± 2% the cell is shut down and the cause of the disagreement is located. In some instances this requires a CVS recalibration. Propane is used instead of carbon monoxide because of the danger of using 100% carbon monoxide.

Chrysler uses Hydrogen-Helium for the FID fuel instead of hydrogen-nitrogen. Chrysler has used this blend and believes this gives the correct hydrocarbon value, recognizing that this fuel will result in a 3% higher reading than the hydrogen-nitrogen fuel.

General comments on the Chrysler central calibration system were made. The forty-one stainless steel lines were freon flushed and if the system has been static for awhile, the NOx lines are run until a steady calibration value is obtained.

EPA

Don Paulsell made the presentation for EPA. Don described the Sample Analysis Correlation (SAC) Program in which a blended gas is placed in a bag and read on all the light duty analyzer sites. The gas is blended using the system shown in Appendix 5. Control limits and control chart flags were discussed and are listed in the Appendix.

The capabilities of the SAC Program include the assessment of site-to-site, range-to-range correlation and repeatability plus the diagnosis of instrument problems. A complete listing of the program capabilities is contained in the Appendix.

Don described EPA's analyzer calibration philosophy, emphasizing that overlapping cal gases are important to ensure range-to-range continuity, and that this practice helps to pinpoint standards that are deteriorating. A common manifold for span gases eliminates the variability of calibration span gases from site-to-site. EPA performs a span check/mid-span check and a quarter-span check during calibration. A summary of the above is contained in the Appendix.

Current EPA analyzer ranges are:

HC (ppm C_3H_8)	LCO (ppm)	HCO (ppm)	CO_2%	NOx (ppm)
0-250	0-1000	0-5000	0-5.0	0-250
0-100	0-500	0-2500	0-2.5	0-100
0-50	0-250		0-1.0	0-50
	0-100			

EPA - NOx Converter Efficiency

The NOx converter efficiency is performed once a week. Although 90% is the corrective action limit, typical values are 98%. A mixture of 1% oxygen in Argon was discussed as a potential ozone source to decrease the sensitivity of the ozonator. A mixer is located in the efficiency checker to ensure a uniform gas.

EPA - Carbon Dioxide-Water Interference

The carbon dioxide and water response on the carbon monoxide analyzers is checked every six months. A typical result of .5 ppm response is experienced, with less than 3 ppm being the maximum allowable response. A Hopcalite (MSA product) scrubber is used to remove the carbon monoxide from the zero air zero gas (Appendix).

EPA - Tracer Gas Injections

Propane injections are performed weekly using the Critical Flow Orifice technique. Don explained that the density of pure propane is 52.72 gms/ft^3 at 68°F and 1 atmosphere whereas diluted propane is 51.88 gms/ft^3. EPA is installing CFO manifold systems using the orifices supplied by Turner Corp. A copy of this information is in the Appendix. EPA has determined that the proper equation to use with a CFO kit is:

$$(SCFM) \quad q = (AP^2 + C) / \sqrt{Tabs}$$

Bomb mass testing is also used at EPA, generally in conjunction with evaporative SHED's (Appendix).

EPA - CVS Systems

Don described the procedure used by EPA in calibrating the PDP and CFV type sampler systems. The equations and plots used can be found in the Appendix. EPA uses a LFE and collects eight data points per calibration with a tolerance of $\pm$ 1% of the curve as acceptable data. EPA does not calibrate through the heat exchanger as Chrysler does. A discussion concerning the traceability to NBS of the Meriam Laminar Flow Elements followed. EPA has sent LFE units to Colorado Engineering Experiment Station, Inc., for recalibration. Copies of typical calibration data are included in the Appendix. The question of how well the calibration supplied by Meriam and a recalibration by the Colorado Engineering Experiment Station, Inc., performed on a new unit agreed was asked. No one present had ever had a new unit recalibrated; only units having prior use had been recalibrated. It was stated that the new units received from Meriam have a calibration traceable to NBS.

GM - Cell-to-Cell Correlation

Mike Briggs explained the technique used by GM to cross check their bag sites. Weekly, a bag of high concentration and a bag of low concentration exhaust emissions are generated using a vehicle and CVS. The bags are initially checked on a reference site, and then analyzed on each cell, operating or not. The reference cell is changed each week. In order to correct for nitric oxide decay, the bags are read periodically on the reference cell during the testing of the other cells. A statistical analysis is made to identify outliers outside of two sigma. Hydrocarbon results will differ and the relative response of the FID is suspected. A GC analysis is also performed on the bag. Mike stated that the mid-span on all bag ranges is checked once daily and must be within ± 2% of the value of the gas.

A zero and span check is performed per each bag group and must be ± 0.2 MV in the pretest and ± 1.0 MV in the post-test check. A digital voltmeter and recorder are used in the test cells.

GM - NOx Converter Efficiency

The NOx converter efficiency is checked daily on the most sensitive range of the analyzer and in accordance with the Federal Register test procedure. The minimum acceptable limit at GM is 98% efficiency. A leak check is performed in conjunction with the efficiency check. Carbon dioxide and water vapor interference on the carbon monoxide analyzers are checked each month. Analyzers must meet the Federal Register specifications.

Additional monthly checks include bag analyzer curves, NDIR optimization, and the FID methane response to approximately 60 ppm methane-air mixture. An equivalent factor of 1.12 ± .02 to C_3H_8 is typical.

GM - CVS System

Tom Slaughter discussed the CVS systems. The GM systems are the Positive Displacement Pump type and are connected to a data acquisition computer. The make-up air supplied to the CVS is provided by an external air supply. Many questions were asked concerning the make-up air and the system used for controlling the humidity, etc.

GM - CVS Calibration

A daily propane injection is run on the CVS system using the CFO technique. A ± 2% agreement is required. GM uses the real gas density of propane and assumes the purity to be 100%. The initial calibration is performed using a LFE on the CVS outlet. GM plans to use a Smooth Approach Orifice instead of the LFE for calibrating the CVS systems because the LFE system calibration changes as the unit gets contaminated.

Agenda Items IV, V, VI, and VII are presented individually as follows:

IV. Dynamometer Systems

Chrysler

Chrysler uses the Clayton, direct drive, variable inertia flywheel and automatic roadload control equipped dynamometers. The dynamometers are operated in the automatic roadload mode with additional control pots added to the initial system to enable the use of the automatic roadload feature on non-standard horsepower settings. In some instances, the dynamometers are operated in the manual mode. Chrysler is planning to add 125 lb. increment inertia weight capability, dial-a-horsepower thumbwheels, and digital speed and horsepower meters to the existing dynamometers. Distance measurement equipment has recently been added to the dynamometers. The dynamometers are calibrated every thirty days.

The roadload horsepower is checked each test as is the speed calibration of the driver's aids. The inertia weight engagement is verified by the test cell operator before the test. A quick coastdown technique has been used by Chrysler to spot check the dynamometer horsepower calibrations. This technique can be performed after the dynamometer warm-up. It requires that the same vehicle be used and instead of lifting the vehicle from the dynamometer, the coast time is recorded while the vehicle remains on the dynamometer. This technique is quick and provides immediate results when the test site is equipped with an on-line data acquisition system.

The roller spacing on all of the dynamometers is 17.25 inches, except for three truck dynamometers, which have a 20.00 inch spacing.

Ford

Ford uses Clayton, direct drive, variable inertia flywheel, roadload control dynamometers with 17.25 inch spacing. The dynamometers are currently operated in the automatic roadload mode. Weekly frictional horsepower and roadload horsepower determinations are performed using the Federal coastdown procedure. Ford has a special vehicle equipped with built in lifts that reduces the amount of time required to perform coastdowns. The driver's aid is checked daily by comparing the number of dynamometer roller revolutions vs. the time at a specific speed with an allowable tolerance of $\pm$ 0.1%. The tach generator voltage versus speed calibration is checked bi-monthly using a digital counter with a tolerance of $\pm$ 10 rpm of the set point.

GM

GM uses the Clayton direct drive, automatic roadload control dynamometers with 17.25 inch roller spacing. The dynamometers are operated in the automatic roadload control mode. The Clayton dynamometers electronics have been modified to provide thumbwheel horsepower selection capability. Further modifications have been made as explained in EPA/Industry Symposium #1.

GM uses a computerized program utilizing the least squares linear curve fit to generate the indicated horsepower versus the actual horsepower data.

The dynamometer rollers have been machined to give a uniform roller circumference and solid bearing supports have been employed. The dynamometers have been aligned using a laser beam.

A full dynamometer speed and horsepower verification is performed every thirty days using a special coastdown vehicle. The speed is calibrated using a line synchronized stroboscope. A horsepower check is performed before and after each test.

EPA

EPA uses the Clayton direct drive variable inertia flywheel, automatic roadload control dynamometers with 17.25 inch roller spacing. EPA operates in the automatic roadload mode. A chart showing the statistics for the distance traveled during the various phases of the FTP and HWFE cycle was discussed. The chart is contained in the Appendix. A brief summary is:

FTP (812 tests)		
Cold transient	-	3.6058 mi.
Cold stabilized	-	3.9010 mi.
Hot transient	-	3.6067 mi.
HWFE (691 tests)	-	10.295 mi.

The rear roller revolutions are monitored using an encoder that gives 320 pulses per revolution, which are totalized at 10/rev.

The EPA calibration techniques and supporting data are contained in detail in the EPA/Industry Symposium #1 proceedings.

V. Total System Checks

Ford uses the exhaust flow simulator daily for a total system check. The simulator uses critical orifices to inject known amounts of emissions components.

Chrysler uses a correlation vehicle on a weekly basis to cross check the total system of each cell. A hot 505 cycle is run using the running start technique. The vehicle oil and water temperatures are stabilized using a 40 mph steady state prior to the test. On a monthly basis vehicles are switched from the Proving Grounds and Highland Park for a facility-to-facility comparison.

The correlation limits are:

	HC	CO	NOx	CO_2
Gms/Mi.	1.40	8.5	3.3	600
% Variation	5.0	10.0	8.0	3.0

	HC	CO	NOx	CO_2
Gms/Mi.	0.5	4.0	2.3	670
% Variation	10.0	15.0	10.0	3.0

Typical data are contained in the appendix.

GM checks each site every day using a vehicle and evaluates the data statistically using a two week moving average. If a cell has two successive CO_2/NOx readings that are are outliers, the dynamometer is checked.

VW stated that an automatic driver reduces data variation on cell-to-cell total systems checks.

Dick Lawrence, of EPA, discussed the effect that the calibration of the thermometers can have on the KH factor. If a facility is using a wet and dry bulb apparatus using mercury thermometers that are not matched, an error can be introduced that will have a significant effect on the KH factor. He further stated that EPA intends to purchase a dewpoint instrument for evaluation.

Don Paulsell stated that an effective cell correlation program should have both small (2000 lb. inertia) and a large (4000 lb. inertia) vehicle involved in the program.

VI. SHED

Chrysler has 3 SHED's at the Proving Grounds, one AESI and two Eller, equipped with internal and external cooling. The AESI is 10' x 8' x 21' with a total volume of 1680 $ft.^3$ and the Ellers are 10' x 10' x 24' with a total volume of 2400 $ft.^3$.

GM Proving Grounds has six SHED's, five with a volume of 1850 $ft.^3$ and one with a volume of 2560 $ft.^3$. The systems were designed by the MVEL. A list of the details is contained in the Appendix.

VII. State-of-the-Art Diagnostic Techniques

Everyone involved in emissions testing is striving to develop quality control monitoring techniques that can be performed during the course of the testing. The amount of non-productive time expended in performing the necessary quality control checks can be reduced, while at the same time providing the assurance that a facility is producing valid data.

Don Paulsell discussed some of the EPA techniques that are part of the data processing program for the FTP and HWFE tests. A list of these parameters and the limits used to assess abnormal data are shown in the Appendix.

A G E N D A

EPA/INDUSTRY QUALITY CONTROL SYMPOSIUM
INTRA-LABORATORY TEST SITE/EQUIPMENT
QUALITY CONTROL TECHNIQUES

October 5, 1977
9:00 A.M. - 4:00 P.M.

I. Bag Analyzer

- Cell-to-Cell Correlation
- Daily Calibration - Range to Range Span Checks
- NOx Converter Efficiency Check
- Water and Carbon Dioxide Interference Checks

II. CVS Systems

- Description of the CVS Systems
- Method of Primary Calibration

III. CVS Systems Sample Integrity

- Tracer Gas - Propane Injection
- Bag Leak Checks
- System Leak Checks
- Hydrocarbon Hangup

- LUNCH 11:30 A.M. - 12:30 P.M. -

IV. Dynamometer System

- Driver's Aid Calibration
- Roller Revolution Monitoring - Distance Measurement Equipment
- Speed Check
- Roadload Horsepower Check
- Frictional Horsepower Check
- Inertia Weight Monitoring and Horsepower Monitoring During Test

V. Total System Checks

- Correlation Vehicles
- Mass Flow Simulator
- Analysis Techniques

- BREAK - 15 MINUTES -

VI. SHED

- Calibration
- Leak Check
- Propane Retention
- Temperature Monitoring
- Background Check

VII. State of the Art Diagnostic Techniques

- Shortcomings of Present Methods
- Productive (during the test) Techniques for Quality Control
- Special Equipment

APPENDIX

1. Attendance List

2. Ford Motor Company

   Agenda Item I - Bag Analyzer
   Agenda Item II - CVS Systems
   Agenda Item III - CVS Systems Sample Integrity

3. Chrysler Corporation

   Agenda Item I - Bag Analyzer
   Agenda Item II - CVS Systems
   Agenda Item III - CVS Systems Sample Integrity

4. General Motors Corporation

   Agenda Item I - Bag Analyzer
   Agenda Item II - CVS Systems
   Agenda Item III - CVS Systems Sample Integrity

5. Environmental Protection Agency

   Agenda Item I - Bag Analyzer
   Agenda Item II - CVS Systems
   Agenda Item III - CVS Systems Sample Integrity

6. Agenda Item IV - Dynamometer System

   a. Ford Motor Company
   b. Chrysler Corporation
   c. General Motors Corporation
   d. Environmental Protection Agency

7. Agenda Item V - Total System Checks

   a. Chrysler Corporation
   b. Environmental Protection Agency

8. Effect of Accuracy of Wet and Dry Bulb Measurement on Kh Factor

9. Agenda Item VI - SHED

   a. Ford Motor Company
   b. General Motors Corporation

10. EPA In-Process Quality Control Techniques

ATTENDANCE ROSTER

EPA/INDUSTRY QUALITY CONTROL SYMPOSIUM
INTRA-LABORATORY TEST SITE/EQUIPMENT
QUALITY CONTROL TECHNIQUES

October 5, 1977
9:00 A.M. - 4:00 P.M.

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9:00 A.M. - 4:00 P.M.

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A T T E N D A N C E   R O S T E R

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9:00 A.M. - 4:00 P.M.

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9:00 A.M. - 4:00 P.M.

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9:00 A.M. - 4:00 P.M.

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9:00 A.M. - 4:00 P.M.

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Address: 5626 - 25th Ave.

Telephone: Kenosha, Wis. 53140

Name: Frank E. Johnson

Company: Chrysler Corporation

Address: P. O. Box 1118, Detroit, Mich. 48288

Telephone: (313) 956-3135

Name:

Company:

Address:

Telephone:

MISCELLANEOUS

	QC CHECK	TECHNIQUE	FREQUENCY	ACCURACY
1.	Wet/Dry Psychrometer	Sling Psychrometer	Daily	$\pm$ 5 grains H_2O/lb air
2.	Test Cell Vacuum Gauge	Mercury Manometer	6 Months	$\pm$ .5 in Hg
3.	Barometer Calibration	Mercury Barometer	Monthly	$\pm$ .01 in Hg

CVS/ANALYZER SYSTEM

	QC CHECK	TECHNIQUE	FREQUENCY	ACCURACY
1.	Analyzer Calibration	Gas Bottle	30 Days	± 1%
2.	NOx Converter Efficiency	per Fed. Reg.	7 Days	97%
3.	CVS Flow Calibration	LFE	6 Months	± .05 const.
4.	CVS Timers	Stopwatch-3 min.	30 Days	± 1 sec.
5.	CVS Verification	Mini-propane or gravimetric	30 Days	± 2%
6.	CVS Temperature Recorder Calibration	Resistance	6 Months	± 1°F
7.	CVS/Analyzer System	Exhaust gas simulator	Daily	± 5%

APPENDIX 2 BRUCE GARDNER, FORD

COPY NUMBER-- 2

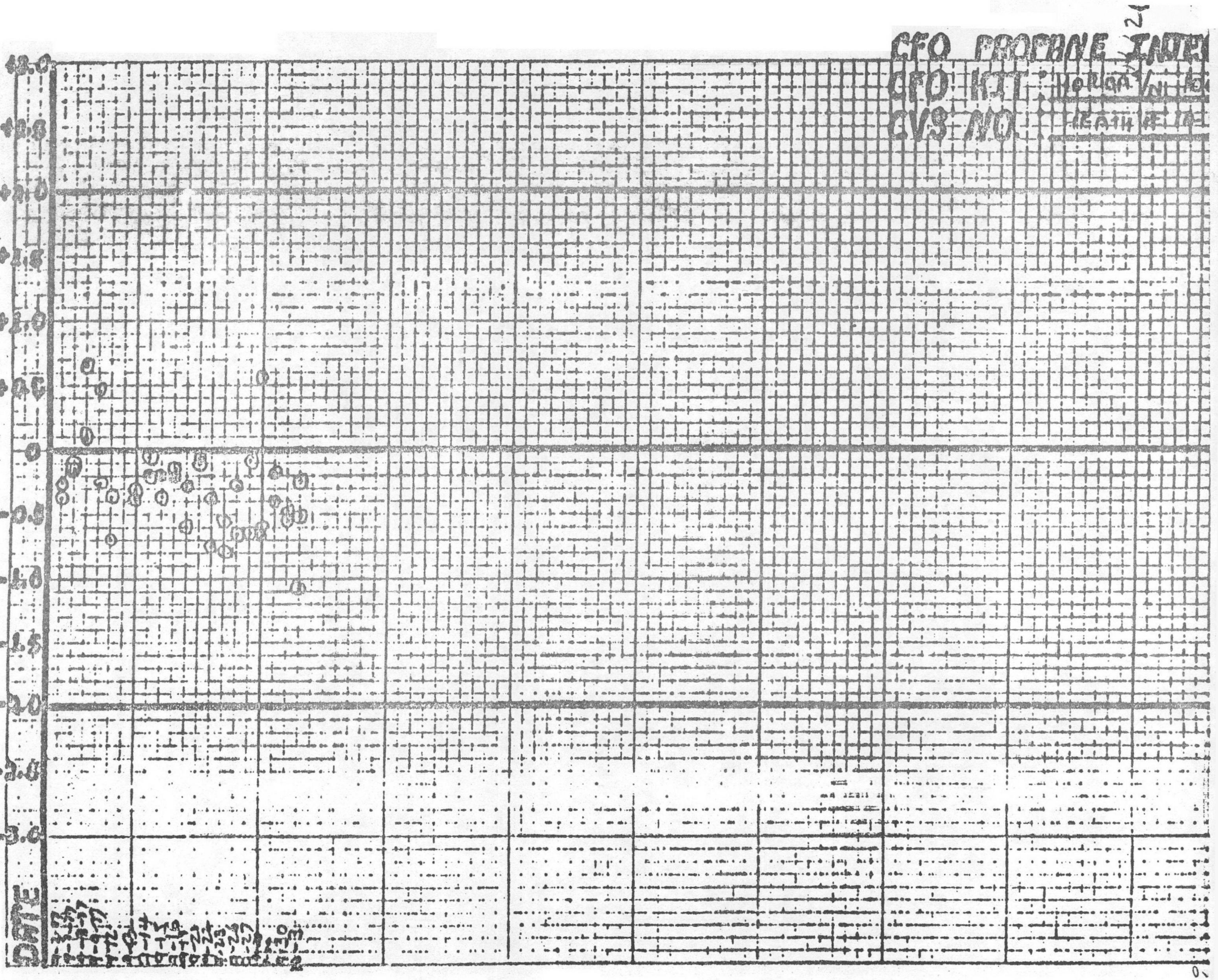
CHRYSLER CORPORATION EMISSION DEVELOPMENT TESTING
B L O W E R C A L I B R A T I O N P R O G R A M

*CVS-HEATH 22 *

LIBRATION PERFORMED ON-03/02/77 BY DOWNEY
OWER SPEED NUMBER THREE
THE LFE USED WAS-F33221R1
IS LFE HAS A SLOPE OF 134.47 AND AN INTERCEPT OF 6.74
E ELEMENT WAS MOUNTED BEFORE THE CVS

S RECALIBRATION WITH 8308 BLOWER HRS.

BLOWER DELTA P	PUMP RPM	CFM	CF/REV
15	1355.9	417.0	.3075
16	1355.0	415.6	.3067
17	1354.2	414.3	.3059
18	1353.3	413.0	.3052
19	1352.4	411.7	.3044
20	1351.6	410.4	.3037
21	1350.7	409.2	.3030
22	1349.9	408.0	.3023
23	1349.0	406.8	.3016
24	1348.1	405.7	.3009
25	1347.3	404.6	.3003
26	1346.4	403.4	.2996
27	1345.6	402.3	.2990
28	1344.7	401.2	.2984
29	1343.8	400.2	.2978
30	1343.0	399.1	.2972
31	1342.1	398.1	.2966
32	1341.2	397.1	.2960
33	1340.4	396.0	.2955
34	1339.5	395.0	.2949
35	1338.7	394.1	.2944
36	1337.8	393.1	.2938
37	1336.9	392.1	.2933
38	1336.1	391.2	.2928
39	1335.2	390.2	.2922
40	1334.4	389.3	.2917



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APPENDIX 3

INSTRUMENTATION VERIFICATION
CVS PROPANE INJECTION W/CFO
CHELSEA PROVING GROUNDS
DEPARTMENT 5150
VEHICLE CERTIFICATION

DATE: 10-4-77

CELL NUMBER	CVS NUMBER	AVERAGE % ERROR*	ENGINEER
1	HEATH 12	-1.1/-0.9	NP
2	" 13	0.6/0.4	JB
3	" 10	0.5/0.8	NP
4	" 14	-0.8/-1.3	NP
5	" 9	-0.4/-0.8	JB
6	" 29	-0.3/-0.4	NP
7	" 11	-1.0/-1.4	NP
8	" 15	1.0/0.4	NP

* Positive errors may be due to:

1) A decrease in:

a) Cubic feet per revolution (CVS flow rate)
b) Inlet temperature
c) Background concentration

2) An increase in:

a) Pump clearance
b) Inlet pressure
c) Barometric pressure
d) Revolution counter
e) Span gases

* Negative errors may be due to the opposite of each of the above positive errors, or to a leak in the CVS or analytical system.

COMMENTS: Any deviations > ±2% must be resolved before the CVS may be used for testing.

$$\text{Calc.: } \frac{[CVS]-[CFO]}{[CFO]} \times 100 = \_\_\_\_\_ \% \text{ Error}$$

ROLLS OPERATORS DAILY CHECK LIST

DATE: 10-3-77 SHIFT: 1 ROLLS: 23 OPERATOR: H. P. SORENSEN

LEAK CHECKS	OK
T.P. BENCH	✓
CO_2 DILUTE	✓
CO_2 EGR	✓
ENG. BENCH	✓
BAG BENCH	✓
C.V.S. SAMPLE SYS.	✓
BAG #1	✓
BAG #2	✓
BAG #3	✓
BAG #4	✓
BAG #5	✓
BAG #6	✓

TUNE-GAIN PRESSURE CHECK

	TUNE	GAIN	SAMP. P.	O_2 P.	H_2 P.	Z. AIR P.
BAG BENCH						
CO	43.1	418	X	X	X	X
CO_2	36.0	800	X	X	X	X
NOx	X	X	4.0	20.0	X	X
HC	X	X	1.5	X	25.0	20.0
T.P. BENCH						
LO CO	34.1	448	X	X	X	X
HI CO	35.0	200	X	X	X	X
CO_2	41.8	620	X	X	X	X
CO_2 DILUTE	341	250	X	X	X	X
CO_2 EGR	38.3	500	X	X	X	X
NO	X	X	4.0	20.0	X	X
HC	X	X	1.5	X	25.0	25.0
ENG. BENCH						
LO CO	40.0	634	X	X	X	X
HI CO	40.0	750	X	X	X	X
CO_2	37.0	700	X	X	X	X
NO	X	X	4.0	20.0	X	X
HC	X	X	1.5	X	25.0	25.0

C.V.S. PARAMETERS	METER	PCS
TEMP.	98	97
INLET DEP.	11.4	11.5
△ PRESS.	21.9	21.9

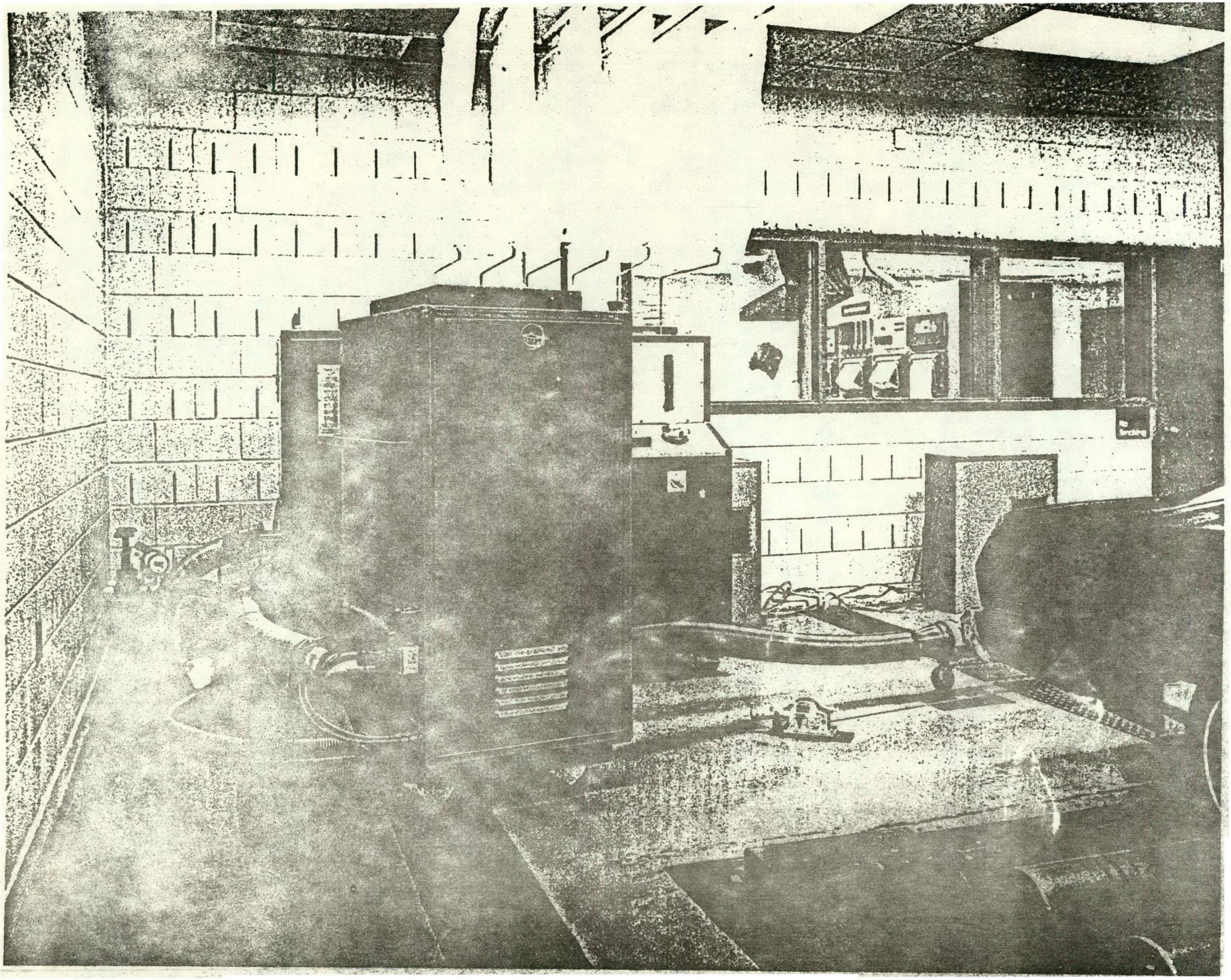
CO_2-H_2O INTERFERENCE CHECK	
RANGE III ZERO	0.0
DRY CO_2 RESPONSE	1.2
WET CO_2 RESPONSE	1.7

BY-PASS FLOW RATE CHECK	
T.P. BENCH	✓
CO_2 DILUTE	✓
CO_2 EGR	✓
ENG. BENCH	✓

5140/HPS

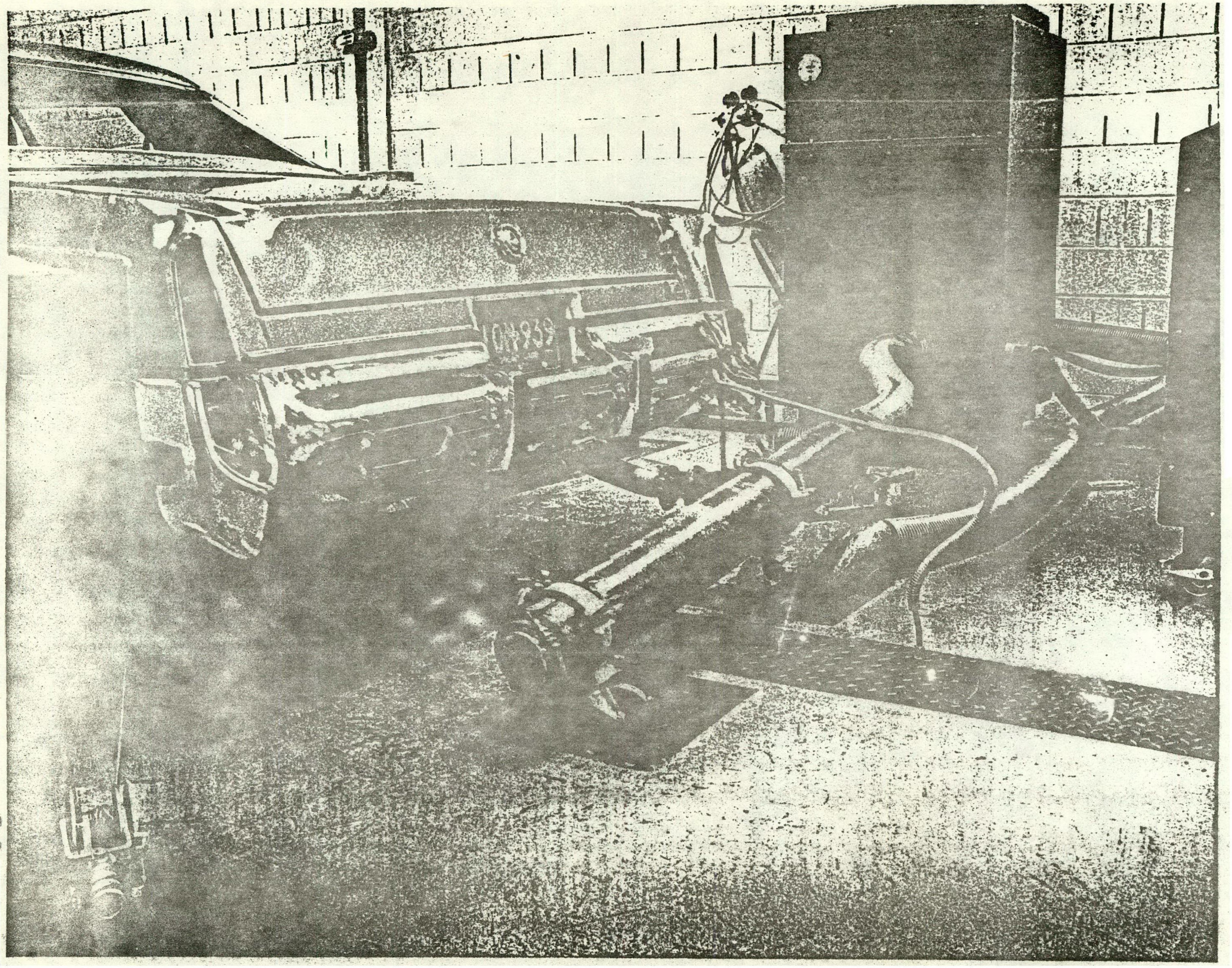
APPENDIX 3

F. JOHNSON CHR.



APPENDIX 3

I. JOHNSON CHAY



F. JOHNSON CH

APPENDIX 3

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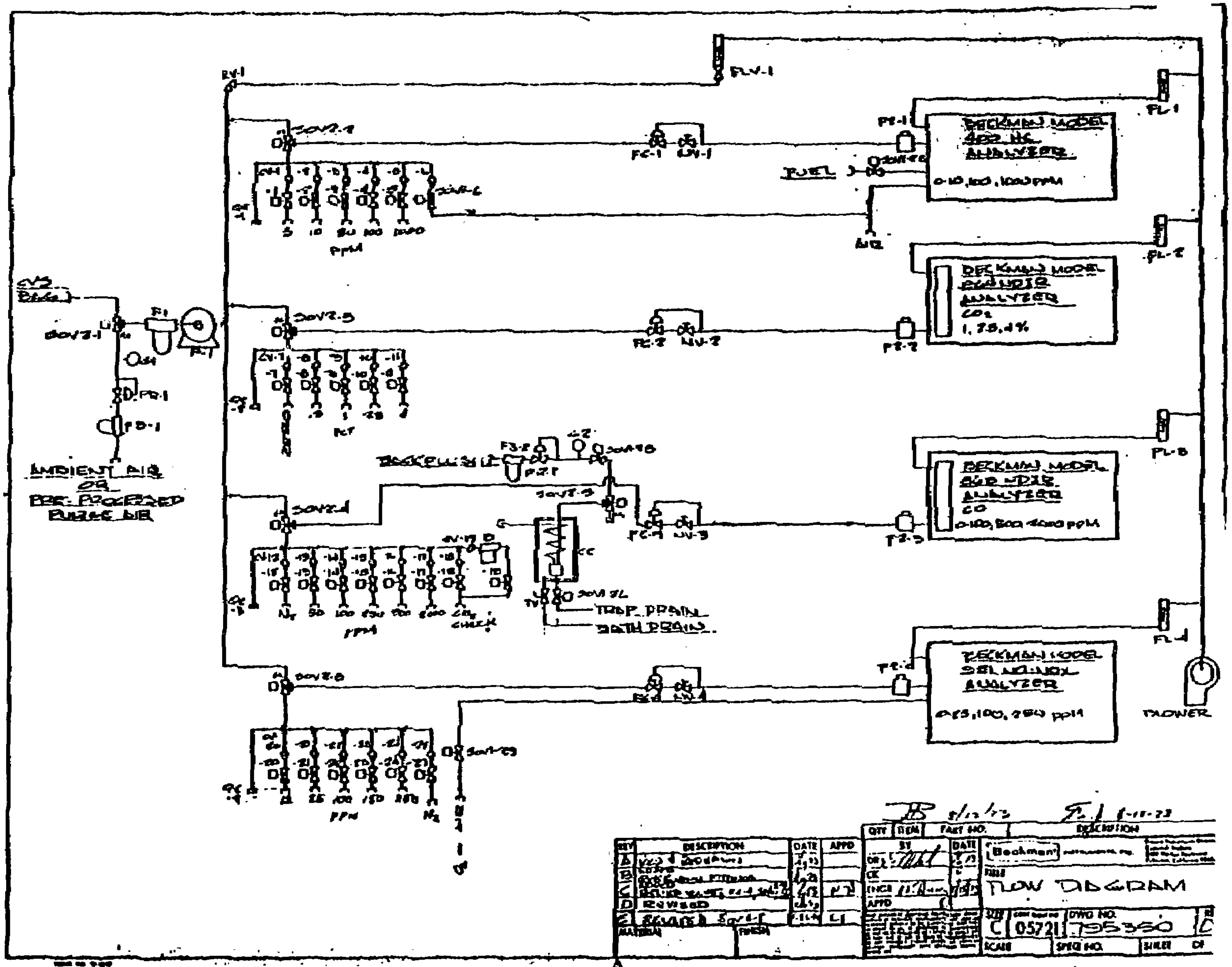

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APPENDIX 3 F. JOHNSON, CHRYSLER

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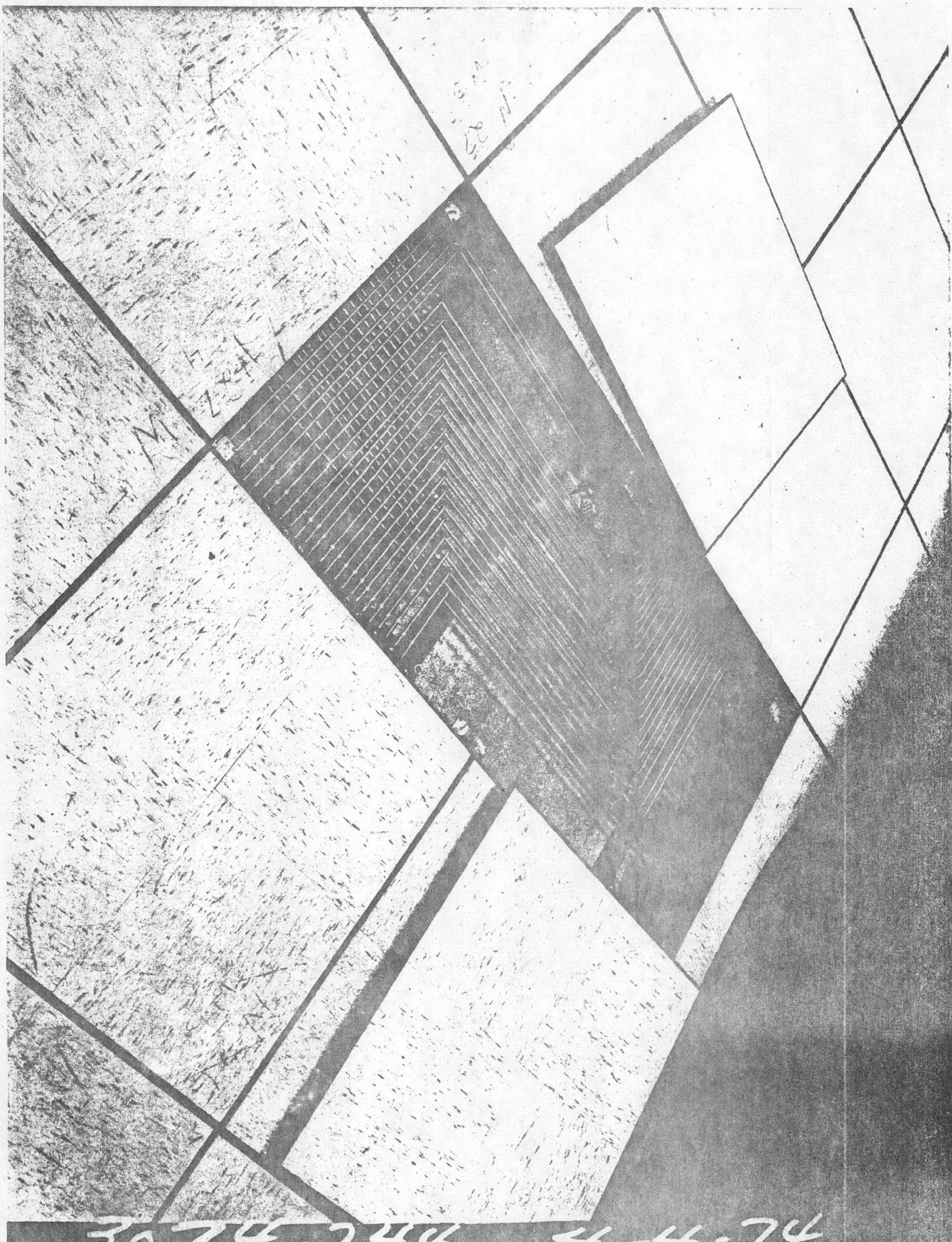
Date________ & Rep.________

.ISSUE DATE	9-8-77	REV. DATE					



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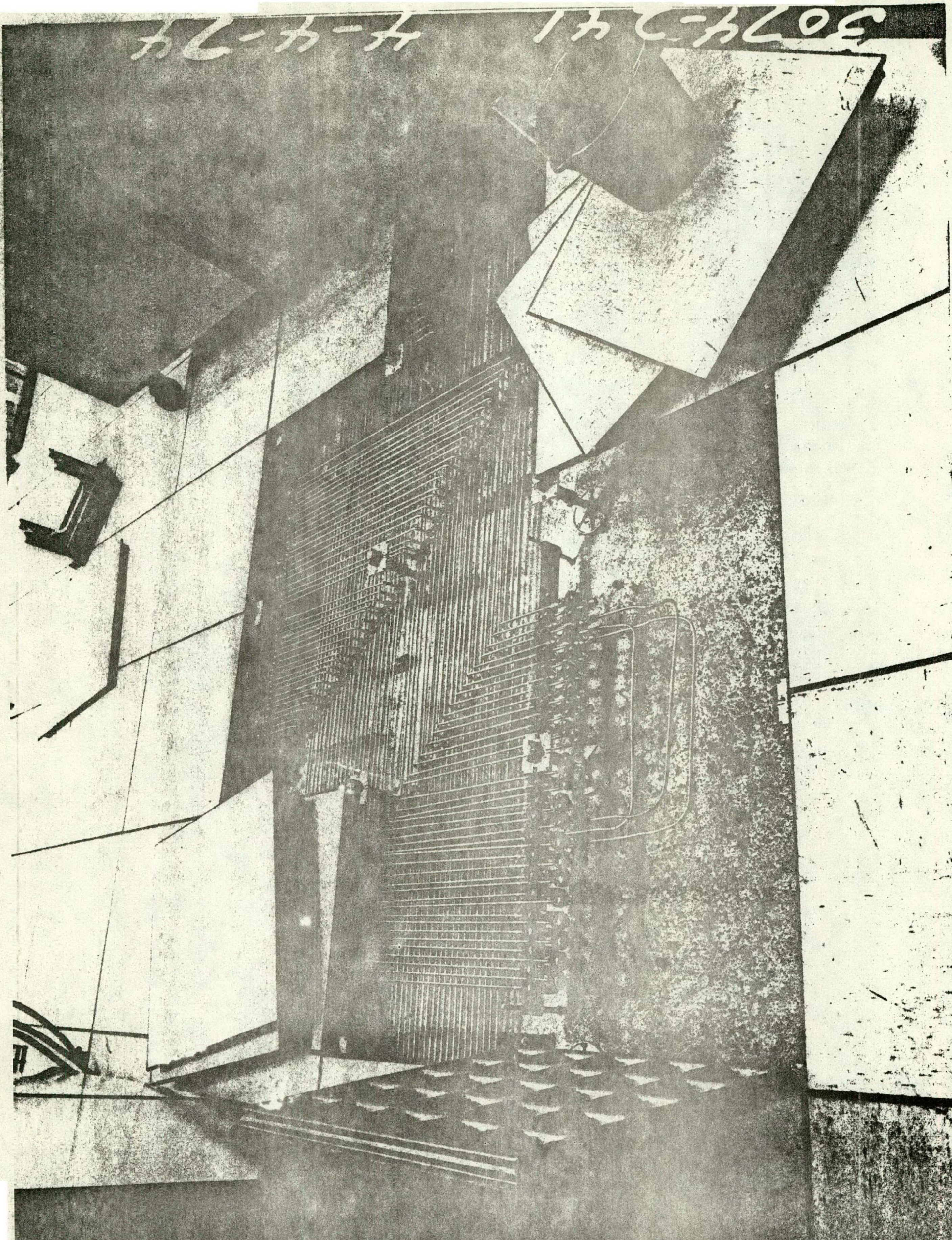
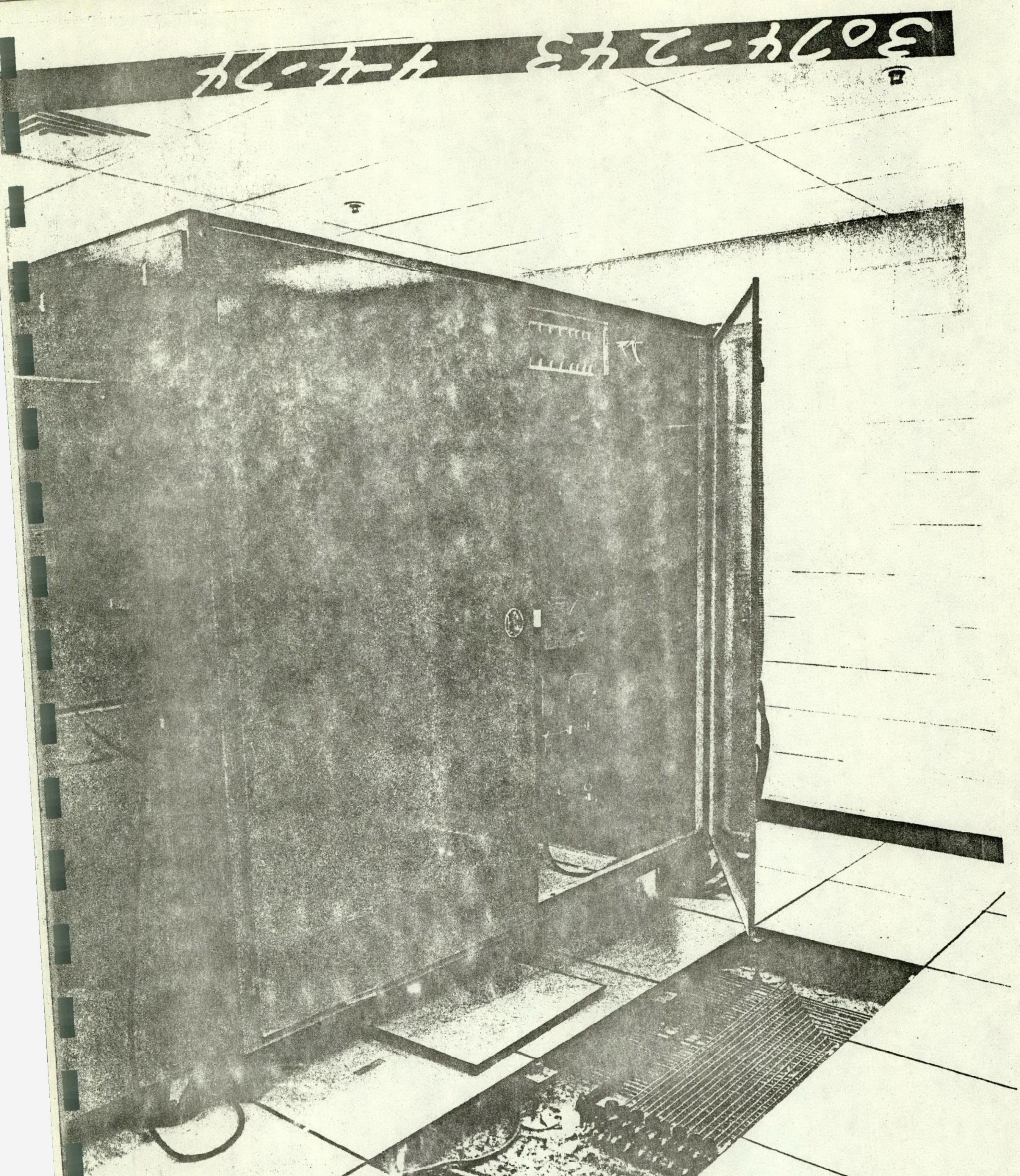
APPENDIX 3 F. JOHNSON CHRV



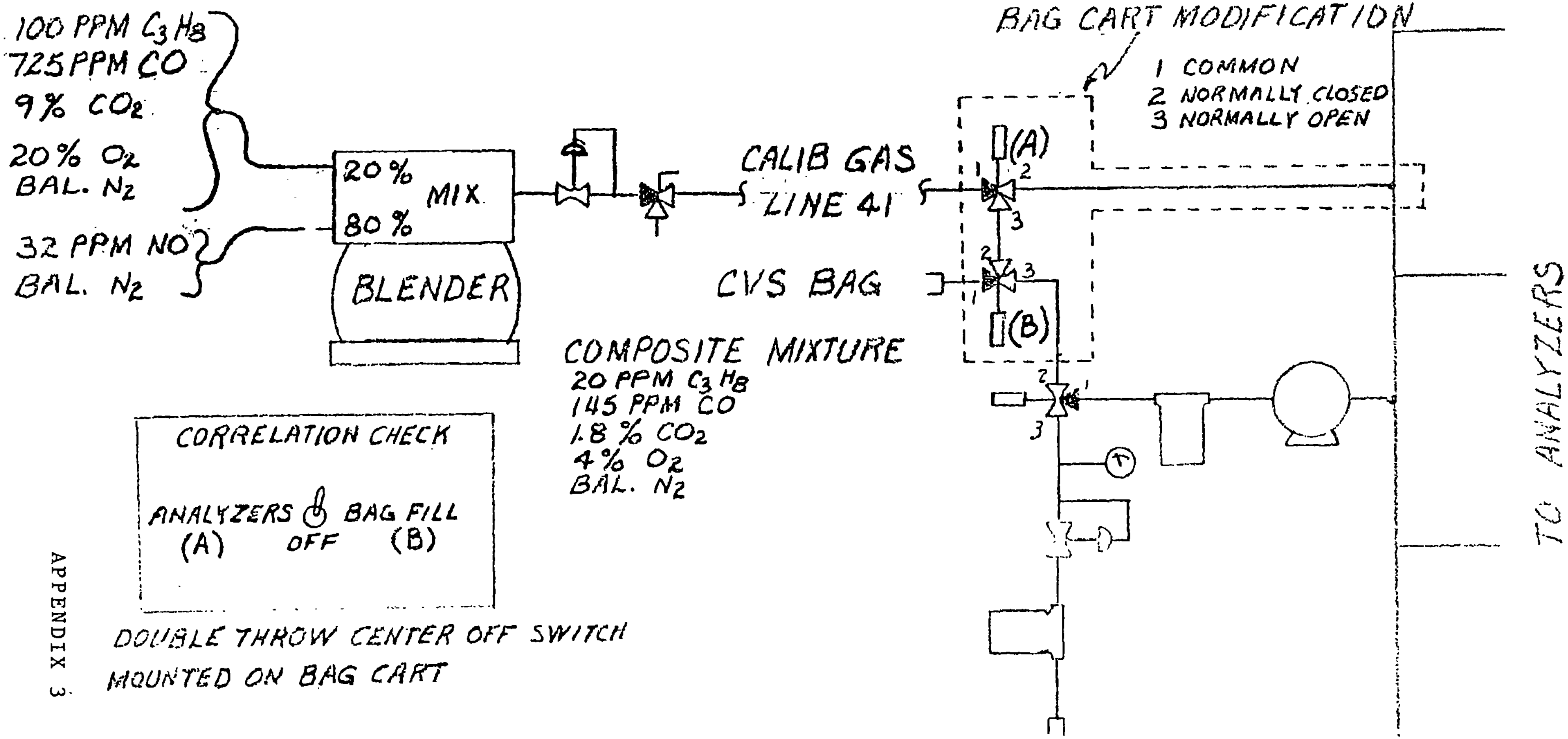
APPENDIX 2

E. JOHNSON CHR



APPENDIX 3

F. JOHNSON CHRY



TO READ TEST GAS:

1.) ANALYTICAL SYSTEM IN "SAMPLE".
2.) SAMPLE PUMP OFF.
3.) SWITCH TO "ANALYZERS."

TO READ BAGS:

1.) OPCON IN "BAG READ".
2.) ANALYTICAL SYSTEM IN "SAMPLE".
3.) SAMPLE PUMP ON.
4.) SWITCH "OFF."
5.) CYCLE OPCON THRU VARIOUS BAGS.

TO FILL BAGS.

1.) OPCON IN "BAG READ."
2.) SAMPLE PUMP "OFF."
3.) SWITCH TO "BAG FILL."
4.) CYCLE OPCON THRU VARIOUS BAG

6-14-77 DRS

AIRCO GAS PROPORTIONERS

MINI-PROPORTIONER®

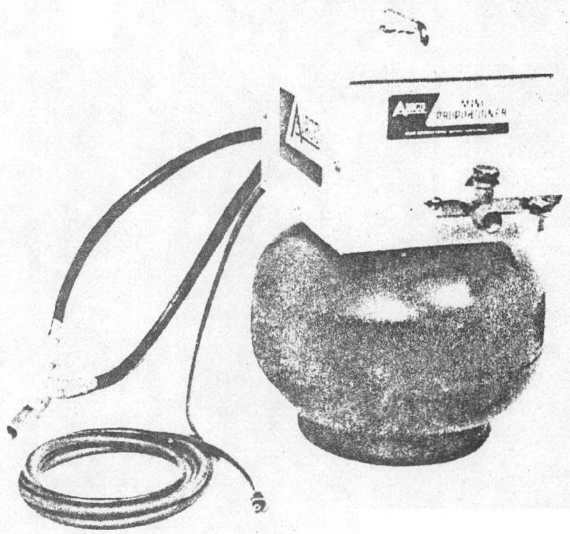
$250.00

805-2000 for 2 Gas Mixtures/805-2001 for 3 Gas Mixtures
A Portable, Extremely Accurate Gas Mixing System

The MINI-PROPORTIONER® is a portable, extremely accurate gas mixing system. Used to blend two or three gases in exact proportions, it is ideal for inert gas welding, atmospheres (forming gas mixtures), generator cooling and other commercial applications.

The MINI-PROPORTIONER® has important features found only in very expensive stationary proportioners. It is a demand type proportioner with built-in mixed gas reservoir and regulator to maintain constant pressure and flow of mixed gas to the work station. High flow capabilities to 200 scfh and a four-station manifold permits up to four operators to use the proportioner simultaneously.

This proportioner is easy to use. Simply connect to gas supply, set supply regulators to 75 psi and the proportioner does the rest. This unit has no electrical requirements, weighs only 30 pounds and can be used anywhere.



Features

- Extremely accurate ± 0.5% of exact mixture.
- Each unit is factory set to meet user's requirements.
- Simple to use
- Constant delivery pressure is maintained by a built in regulator. Set at 15 or 30 psig.
- Economical
- Weighs only 30 pounds.
- A unique mechanical cycler precisely controls mixing.
- Demand Proportioner utilizes a mixed gas reservoir with safety relief valve.
- Manifold has 4 outlets.
- High gas flow capability — to 200 scfh.

Benefits

Accurate gas mixtures for protective welding atmospheres.

Tamper proof — Operator cannot inadvertantly change gas mixture.

Minimum set up time

Versatile

Eliminates the need to buy pre-mixed gas

Portable — easily carried and used anywhere

No electrical requirements

Minimum maintenance — no solenoids to replace

Safety — Internal pressure protection

As many as 4 operators can use the MINI-PROPORTIONER® at once.

For increased capacity two or more MINI-PROPORTIONERS® may be used in parallel.

Specifications:

Inlet Connections:

Major Gas — 5/8–18 R.H. Internal

Minor Gas — 5/8–18 R.H. External for CO_2, argon, helium or nitrogen
— 9/16–18 R.H. Internal for oxygen
— 9/16–18 L.H. Internal for hydrogen

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ADDENDUM 2   F. JOHNSON

MINI-PROPORTIONER® (continued)

Outlet Manifold has 4 ea. ¼" N.P.T. Internal Threads
2 Plugged
2 Valves with ⅝-18 R.H. Internal Threads

Delivery Pressure 15 or 30 psi (preset).

Inlet Pressure 75–100 psi depends on outlet pressure.

Max Flow 160–400 scfh (most mixtures 200 scfh).

Capable of 2 or 3 gas mixtures in any proportion — Gases include argon, CO_2, oxygen, nitrogen, helium and hydrogen (except for explosive mixtures).

How To Order

1. Specify the stock number of the appropriate proportioner.
   Stock no. 805-2000 for mixing 2 gases.
   Stock no. 805-2001 for mixing 3 gases.
2. Specify the gases to be mixed and the mixture by percent of each gas.
3. Specify delivery pressure requirements.

NOTE: The proportioner is factory set to deliver at 15 p.s.i.g. unless otherwise specified.

Equipment Required for Accurate Control

Regulators — The MINI PROPORTIONER® is calibrated at 75 p.s.i.g. inlet pressure. Two stage regulators with delivery capability of 75 p.s.i.g. are recommended. Airco regulators are listed below:

Cylinder Regulators

Gas Service	Stock No.	2½" PSI Pressure Gauges	Max. Flow CFH	Max. Work Pressure PSI	Connections		
					CGA No.	Inlet	Outlet
CO_2*	806-8005	200 & 2000	135	120	320	.830-14 R.H. Int.	"B" ⅝-18 R.H. Int.
Argon Nitrogen	806-8420	200 & 4000	975	100	540	.908-14 R.H. Int.	"B" ⅝-18 R.H. Int.
Argon Helium Nitrogen	806-9402	200 & 4000	975	100	580	.960-14 R.H. Ext.	"B" ⅝-18 R.H. Int.
Nitrogen	806-8427	200 & 4000	975	100	550	.908-14 L.H. Int.	"B" ⅝-18 R.H. Int.
Hydrogen	806-9453	200 & 4000	975	100	350	.830-14 L.H. Int.	"B" 9/16-18 L.H. Ext.
Oxygen	806-8456	200 & 4000	975	100	540	.908-14 R.H. Int.	"B" 9/16-18 R.H. Ext.
Helium	806-9458	200 & 4000	975	100	350	.830-14 L.H. Int.	"B" ⅝-18 R.H. Int.

*806-8005 is an electrically heated CO_2 regulator.

Flow Control Equipment:

To fully benefit from the economies resulting from proportioning gases, flow control equipment should be used. Airco general purpose (universal) flowmeters are listed for your convenience.

Fixed flow adapters are also available for use where optimum constant flow rates are known. See ADI 1763 for details.

Universal Flowmeters

STOCK NO.	DESCRIPTION	FLOW RANGE (S.C.F.H. AIR)	
801-0430	Single Range General Purpose Flowmeter	3-56 @ 15 PSIG 4-68 @ 30 PSIG	
805-1606	Dual Range General Purpose Flowmeter	Low Scale	2-23 @ 15 PSIG 2-28 @ 30 PSIG
		High Scale	30-180 @ 15 PSIG 35-220 @ 30 PSIG

APPENDIX 3 - F. JOHNSON CHRY

C.V.S. SAMPLING SYSTEM CORRELATION

CRITICAL FLOW BLENDER

WEEK OF 9/19/77

		ROLLS 20	ROLLS 21	ROLLS 22	ROLLS 23	ROLLS 24	ROLLS 25	ROLLS 26	ROLLS 27
SPAN GAS CALIB.	HC	DOWN	198.5	198.5	198.4	198.3	198.4	198.3	198.5
	CO		1411.7	1410.8	1414.2	1414.4	1409.0	1411.4	1416.4
	CO_2		3.04	3.04	3.03	3.04	3.04	3.04	3.03
	NOx		207.7	207.7	207.0	207.7	207.5	207.9	207.4
DIR. FROM BLEND.	HC	DOWN	167.8	166.4	166.6	166.5	165.6	166.6	166.3
	CO		1958.2	1992.2	1957.6	2003.4	1999.0	2010.2	2031.3
	CO_2		2.64	2.60	2.61	2.61	2.61	2.62	2.61
	NOx		148.0	148.6	147.3	147.9	145.8	148.7	148.7
BAG #1	HC	DOWN	168.2	163.7	167.6	168.0	165.0	165.5	164.1
	CO		1954.3	1990.1	1974.2	1998.3	1987.3	1999.8	2005.6
	CO_2		2.66	2.60	2.62	2.60	2.61	2.61	2.59
	NOx		150.4	137.7	149.6	154.9	144.3	142.6	145.9
BAG #2	HC	DOWN	166.1	163.9	166.5	165.3	165.3	166.1	166.5
	CO		1931.2	1995.3	1962.4	1999.4	1991.6	2003.0	2029.9
	CO_2		2.62	2.61	2.60	2.60	2.61	2.62	2.61
	NOx		146.3	139.3	146.1	156.2	147.3	146.0	149.9
BAG #3	HC	DOWN	166.3	163.7	166.6	165.0	165.2	166.2	165.1
	CO		1929.3	1988.7	1974.2	1999.6	1990.2	2004.8	2013.8
	CO_2		2.62	2.61	2.60	2.60	2.61	2.62	2.59
	NOx		147.2	140.7	147.4	156.2	148.1	147.0	148.7
BAG #4	HC	DOWN	167.1	163.8	166.9	165.1	165.8	166.3	165.6
	CO		1946.6	1980.7	1982.8	2000.5	1998.7	2001.2	2021.6
	CO_2		2.64	2.59	2.60	2.60	2.62	2.62	2.61
	NOx		148.4	142.4	147.9	156.7	148.9	147.3	149.7
BAG #5	HC	DOWN	165.0	165.4	166.8	164.8	165.9	165.4	164.0
	CO		1933.7	1992.3	1976.7	1996.6	1998.1	1991.2	1999.8
	CO_2		2.61	2.61	2.61	2.60	2.61	2.60	2.58
	NOx		147.1	144.6	147.8	156.6	149.5	146.5	148.1
BAG #6	HC	DOWN	166.9	165.4	166.4	164.4	165.3	165.8	164.8
	CO		1942.7	1993.5	1968.6	1992.1	1995.7	1994.0	2010.6
	CO_2		2.63	2.60	2.60	2.59	2.61	2.61	2.58
	NOx		14[illegible].2	144.7	147.8	156.0	149.0	147.0	149.2
DIR. FROM BLEND.	HC	DOWN	168.3	167.0	167.4	165.0	166.9	166.5	166.1
	CO		1958.1	2002.8	1982.4	2000.0	2005.2	2004.8	2032.9
	CO_2		2.65	2.62	2.61	2.59	2.62	2.63	2.61
	NOx		148.3	148.1	149.4	156.6	150.1	149.7	149.7

DIRTY NOX analyzer

5140 RAN 8/8/77

APPENDIX 3

E. JOHNSON CHRN

C.V.S. SAMPLING SYSTEM CORRELATION
CRITICAL FLOW BLENDER

WEEK OF 9/25/77

		ROLLS 20	ROLLS 21	ROLLS 22	ROLLS 23	ROLLS 24	ROLLS 25	ROLLS26	ROLLS 27
SPAN GAS CALIB.	HC	DOWN	DOWN	198.5	198.8	198.3	198.3	197.7	198.4
	CO			1412.2	1410.8	1483.4	1482.0	1481.1	1410.2
	CO_2			3.04	3.04	3.04	3.03	3.04	3.03
	NOx			207.6	207.6	207.6	207.6	207.7	207.5
DIR. FROM BLEND.	HC	DOWN	DOWN	168.4	167.7	168.2	169.4	167.2	167.0
	CO			2025.6	1930.5	2018.2	2010.2	2000.0	2037.7
	CO_2			2.64	2.61	2.67	2.63	2.62	2.62
	NOx			148.4	151.4	148.3	142.3	146.9	147.8
BAG #1	HC	DOWN	DOWN	164.8	167.4	167.8	168.6	166.8	167.1
	CO			1979.9	1927.5	2013.6	2025.8	1993.0	2022.7
	CO_2			2.63	2.61	2.66	2.63	2.62	2.62
	NOx			138.6	148.8	146.3	143.8	142.7	147.3
BAG #2	HC	DOWN	DOWN	165.4	168.5	168.3	169.4	167.9	167.6
	CO			1989.4	1938.3	2015.9	2032.3	2008.9	2030.5
	CO_2			2.64	2.63	2.67	2.63	2.65	2.62
	NOx			141.2	150.1	148.0	149.0	145.3	146.8
BAG #3	HC	DOWN	DOWN	165.4	168.5	168.0	168.1	168.1	166.9
	CO			1993.4	1938.4	2012.7	2025.5	2010.2	2026.2
	CO_2			2.64	2.64	2.67	2.63	2.65	2.62
	NOx			142.2	150.6	148.3	146.2	146.3	148.6
BAG #4	HC	DOWN	DOWN	163.2	168.8	168.1	169.0	168.2	167.1
	CO			1959.7	1943.5	2012.8	2029.4	2010.2	2026.6
	CO_2			2.60	2.64	2.67	2.64	2.65	2.62
	NOx			140.6	150.8	148.7	147.0	146.4	148.6
BAG #5	HC	DOWN	DOWN	165.2	168.6	168.2	169.7	167.7	162.9
	CO			1985.4	1942.3	2012.4	2036.1	2007.1	1968.8
	CO_2			2.63	2.64	2.67	2.64	2.64	2.55
	NOx			142.2	150.7	148.8	148.3	146.1	~~145.2~~
BAG #6	HC	DOWN	DOWN	165.4	168.7	168.4	169.3	168.4	167.4
	CO			1994.0	1946.1	2011.0	2026.2	2014.5	2027.9
	CO_2			2.64	2.64	2.67	2.64	2.66	2.62
	NOx			143.0	150.9	148.8	147.0	146.7	149.1
DIR. FROM BLEND.	HC	DOWN	DOWN	167.9	168.2	170.3	170.8	169.2	166.4
	CO			2023.7	1947.2	2017.6	2037.4	2023.1	2034.4
	CO_2			2.64	2.64	2.67	2.65	2.66	2.62
	NOx			148.8	150.7	148.7	149.5	148.2	150.7

5140 RAN 8/8/77

APPENDIX 3

E JOHNSON CHRV

HEATH INTERNATIONAL, INC. (RICHMOND INSTRUMENTS)

6-BAG CONSTANT VOLUME SAMPLER WITH REMOTE FILTER BOX

HEAT EXCHANGER, AIR INLET HEATED AND WATER COOLED

SUTORBILT BLOWER

4 SPEED LOUIS ALLIS PACEMAKER MOTOR

RANGE 3 PRIMARY RANGE USED, 380-400 CFM

APPENDIX 3 F. JOHNSON CHR

BAG CROSS-CHECK

- 2 CONC. LEVELS
- CORR. FOR NO DECAY
- STATISTICAL SEARCH FOR OUTLIERS
- WEEKLY

MIKE BRIGGS CMPG

MIDRANGES

- ALL BAG RANGES
- ±2 % LIMIT

ZERO/SPAN

- PER BAG "GROUP"
- "PRE" : ±0.2 mV
- "POST" : ±1.0 mV

NOX CONVERTER EFF.

- FED. REG. PROCEDURE
- DAILY
- LIMITS:
    - 98%
    - LEAK CHECKS

MIKE BRIGGS GMPG

LEAK CHECKS

- PROPANE INJECTION
- BAG CROSS CHECK
- BULK STREAM LEAK
- SAMPLE SYSTEM LEAK

MIKE BRIGGS GMPG

MONTHLY CHECKS

- H_2O & CO_2 INT.
- BAG CURVES
- FID METHANE RESPONSE
- NDIR OPTIMIZATION

OTHER CHECKS

- CO_2 BAG CONCENTRATIONS
- CVS REVS, P_{in}, ΔP
- ROLL REVS
- DVU

MIKE BRIGGS GMPG

CVS SYSTEM

Description

- Positive Displacement Pump
- Electronic Transducers - Pressure and Temperature
- Continuous Monitoring of CVS Parameters
- Computer Data Acquisition During Testing
- External Source of Dilution Air Supply

Calibration

- Not on a 30-Day Schedule
- Calibration Verified by Propane Injection
- Propane Injections Performed Daily
- Flow Device - LFE
- LFE on the Outlet
- Plan to use SAO Technique
- Calibration Data Review and Validation

T.L.S. - 10/5/77
G.M.P.G.

CFO PROPANE INJ.

- DAILY
- ±2% AGREEMENT REQ'D
- ASSUME PURE PROPANE
- USE REAL GAS DENSITY

MIKE BRIGGS GMPG

ANALYZER CALBRATIONS

A. STANDARDIZE INSTRUMENTS, RANGES, AND CALIBRATION GASES

1. CELL LENGTH (%NL), FID FUEL
2. OVERLAPPING CALGASES
3. COMMON MANIFOLD FOR SPAN GASES

B. MONITOR SECONDARY CURVE DEVIATIONS TO DETECT DEGRADATION AND TO BETTER ESTIMATE VALUES

C. RANGE-TO-RANGE CHECKS

1. SPAN, MIDSPAN, QTR. SPAN

APPENDIX 5 DON PAULSELL - EPA

EPA ANALYZER RANGES

HC	LCO	HCO	CO_2	NO_x
250	1000	5000	5.0%	250
100	500	2500	2.5%	100
50	250		1.0%	50
	100			

APPENDIX 5

DON PAULSELL - EPA

SAC PROGRAM CAPABILITIES

A. ASSESSES SITE/SITE, RANGE/RANGE CORRELATION AND REPEATABILITY

B. DIAGNOSES INSTRUMENT PROBLEMS

1. SPAN GAS VALVE LEAKS
2. " " SET POINT ERROR
3. CURVE SHIFT
4. FID BURNER DETERIORATION
5. CL CONVERTER EFF. LOSS
6. SAMPLE SYSTEM INTEGRITY

APPENDIX 5

DON PAULSELL - EPA

NO_X CONVERTER EFFICIENCY

1. PERFORM ONCE PER WEEK
2. MINIMUM 90%, TYPICALLY 98+ %
3. MIXER IN EFFICIENCY CHECKER
4. 1% O_2/AR FOR OZONE SOURCE

CO_2/H_2O INTERFERENCE

1. HOPCALITE + ZERO AIR ⇒ CO IN N_2 ZERO GAS
2. 3% CO_2/N_2 BUBBLED THRU H_2O
3. <3 PPM MAXIMUM, TYPICALLY .5 PPM

APPENDIX 5

DON PAULSELL - EPA

SAMPLE ANALYSIS CORRELATION

A. ONE BAG/DAY — ALL LD ANALYZER SITES

B. TWO WEEK ROTATION SCHEDULE

C. CONTROL LIMITS

	HC	CO	CO_2	NO_x
±1 SIGMA	1.8%	1.6%	.90%	1.9%

D. CONTROL CHART FLAGS

- 5 CONSECUTIVE +/-

  4/5 EXCEED 1 SIGMA

  2/3 EXCEED 2 SIGMA

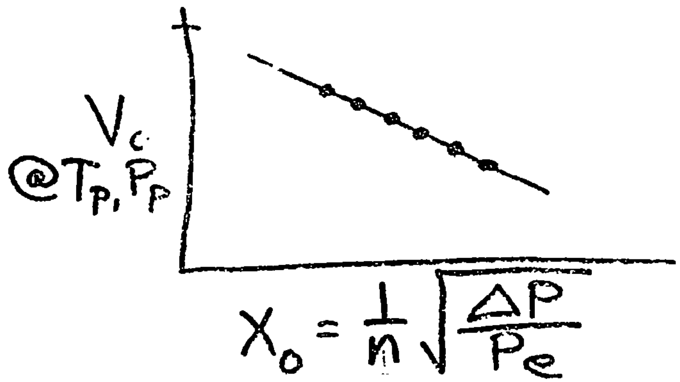
  TEST EXCEEDS 3 SIGMA

APPENDIX 5

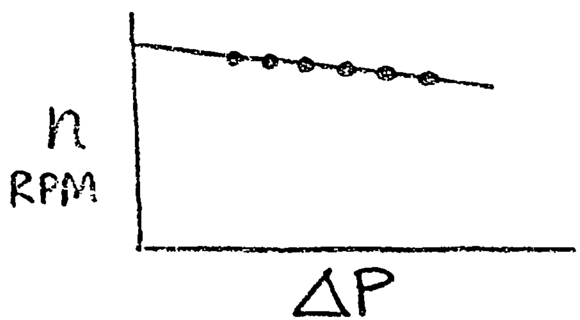
DON PAULSELL EPA

CVS CALIBRATION

A. PDP TYPE



$$V_o = m \cdot \left(\frac{1}{RPM_T} \sqrt{\frac{\Delta P}{P_e}} \right) + b$$



$$RPM_T = n \cdot \Delta P + a$$

$$RPM_A = \frac{REVS \cdot 60}{SECONDS}$$

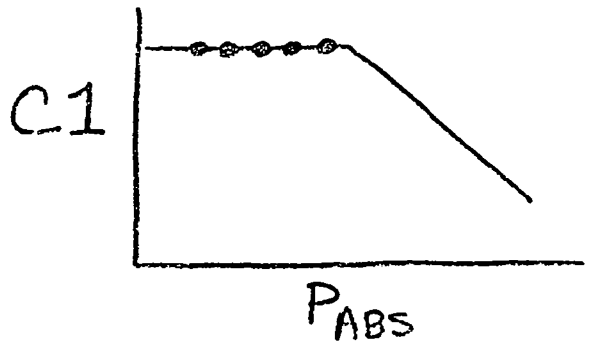
$$RPM_{RATIO} = \frac{RPM_A}{RPM_T} = 1.00 \pm .01$$

APPENDIX 5

DON PAULSELL - EPA

CVS CALIBRATION

B. CFV TYPE



$\sigma_{C1} = \pm .3\%$

$$Q_{THEO.} = 9.2853\, D^2 \sqrt{T_{ABS}}$$

D = THROAT DIAM. (IN.)

T_{ABS} = INLET (°R)

Q_{MEAS} = LFE FLOW @ CFV INLET COND.

$$Q_{RATIO} = \frac{Q_{MEAS}}{Q_{THEOR}} \Rightarrow \approx .985 - .990$$

TYPICAL

APPENDIX 5

DON PAULSELL EPA

TRACER GAS INJECTIONS

A. DENSITY VALUES FOR C3H8 (INSTRUMENT GRADE 99.5+)

1. PURE = 52.72 GMS/FT.^{3} (BEATTIE-BRIDGEMAN)
2. DILUTE = 51.88 " " (IDEAL GAS LAW)

B. CFO VS BOMB

- COMPARE ON MASS BASIS
- TO CONVERT $Q_{S_{CFO}} \Rightarrow M$, USE 52.72 VALUE
- BOMB MASS IS DIRECT $\Delta M \pm .002$ GMS.

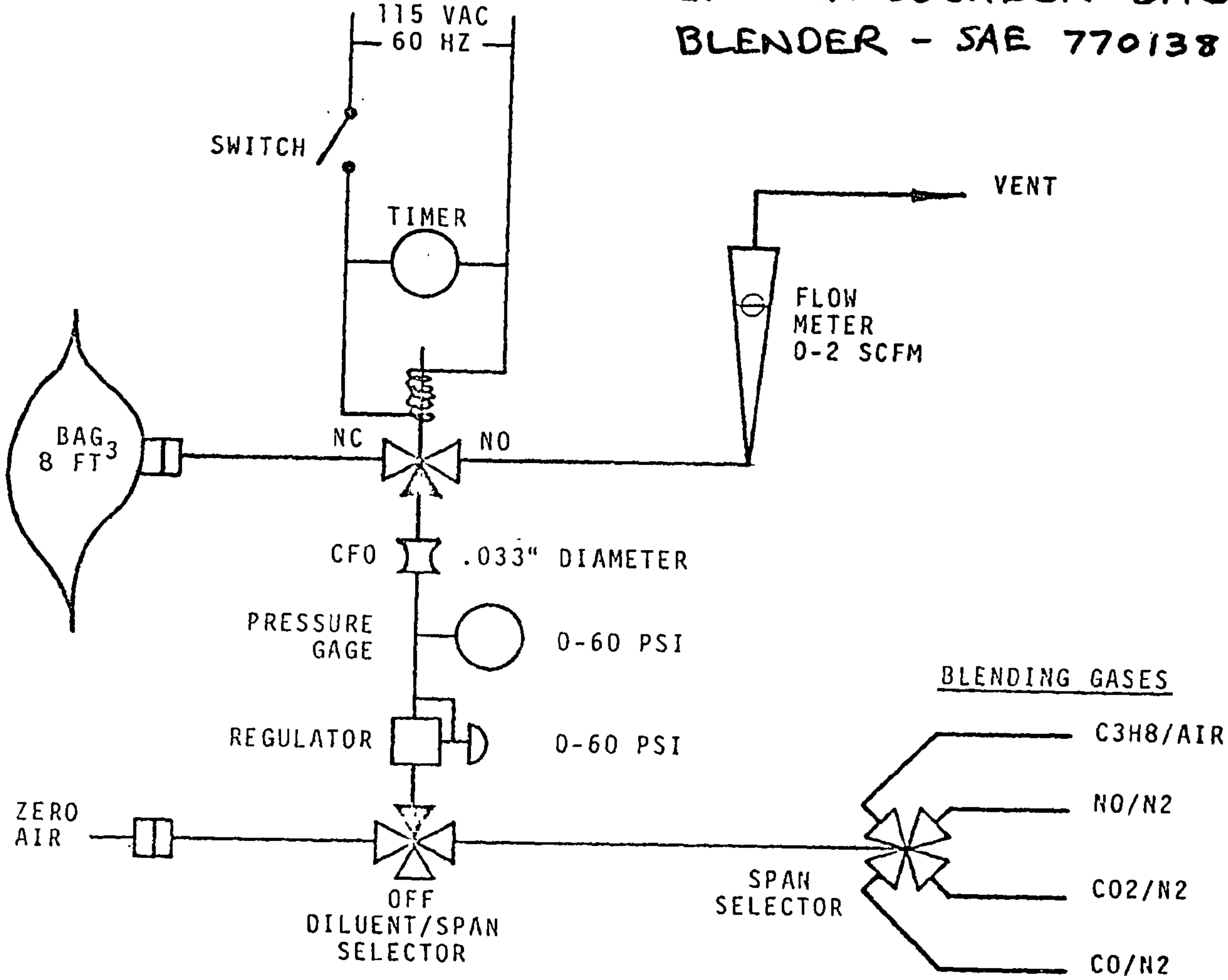
C. TRACER GAS MANIFOLD

- CFO FABRICATION
- CFO CALIBRATION $\left(Q = \frac{A \cdot P^2 + B \cdot P + C}{\sqrt{T}}\right)$

APPENDIX 5

DON PAULSELL EPA

CFO CROSSCHECK BAG BLENDER - SAE 770138



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APPENDIX 5

D. PAULSELL EPA

Turner
821 Park Avenue
Sycamore, Illinois 60178
(815) 895-4545

November 16, 1976

U.S. Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, Michigan 48105

Attention: Mr. Don Taulsell

Dear Mr. Taulsell:

Transmitted herewith are copies of Turner Company drawings SO-0001 and SO-0002 depicting our standard orifices and LP-3833, the filter used with those orifices. As we discussed yesterday, we buy the orifices from:

Starro Precision Products, Inc.
37 North Union Avenue
Elgin, Illinois 60120
Tel: 312/741-3382

And the filters are made by:

Sintered Metals Inc.
3390 Washington Avenue
Boston, Massachusetts 02130

If further information is required or if I can be of assistance in any way please contact me.

Very truly yours,

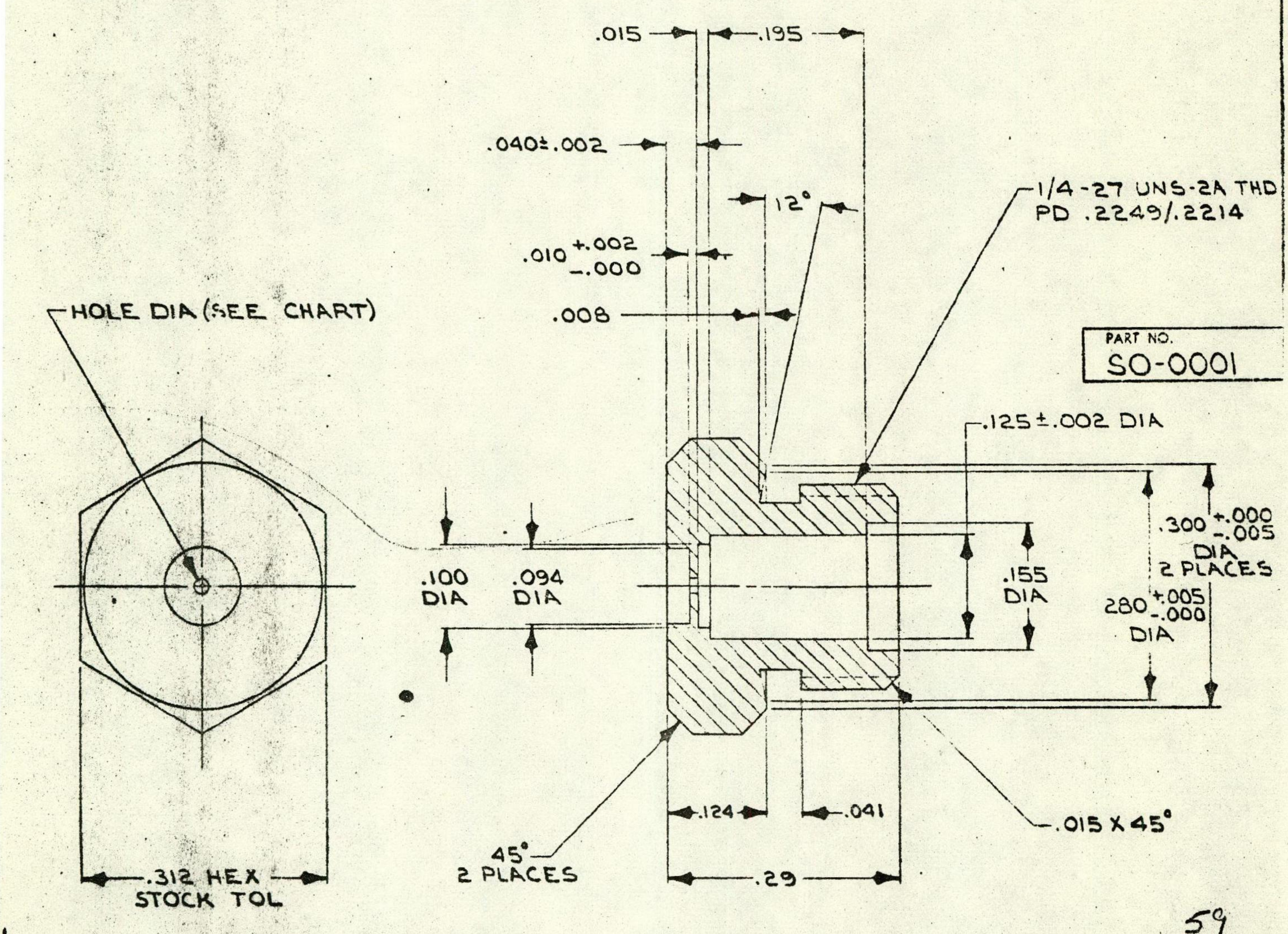
George Barton, P.E.
Manager, Operations Engineer

NOTE: THE ORIFICE IN THIS PACKAGE WAS CALIBRATED FOR USE IN A PROPANE CFO MANIFOLD AT EPA.

A Division of
Cleanweld Products, Inc

APPENDIX 5 D. PAULSELL EPA

PART NO.	DESCRIPTION NO.	HOLE DIA	IDENTIFICATION
P-4029-R	SO-0001-135	.0135 +.0005 -.0000	PLAIN - NICKEL FLASH BEFORE DRILLING



MATL. 5/16 HEX FCY
BRASS ROD
NO. 006 213 04

DO NOT SCALE DRAWINGS
STANDARD TOLERANCES
.XX DEC. ± .015
.XXX DEC. ± .005
ANGLE ± 1°

SUPERCEDES

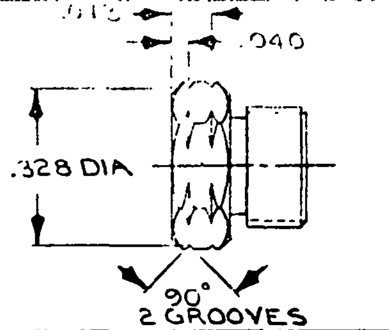
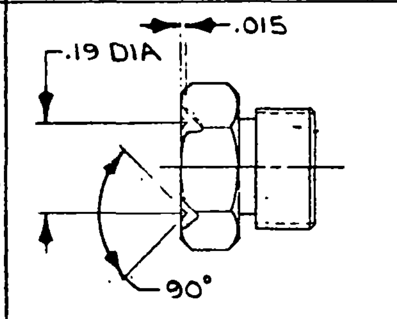
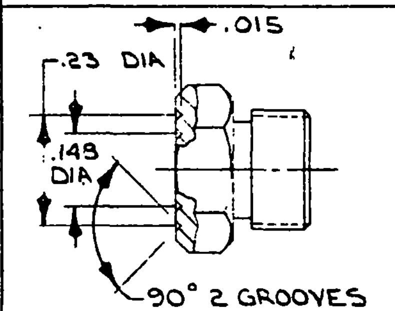
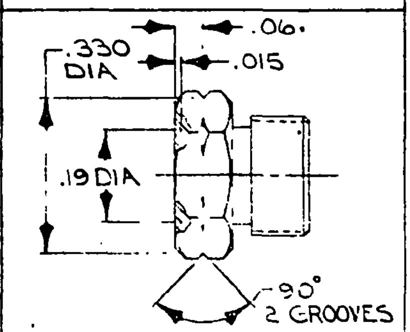
FINISH:

SCALE 8=1

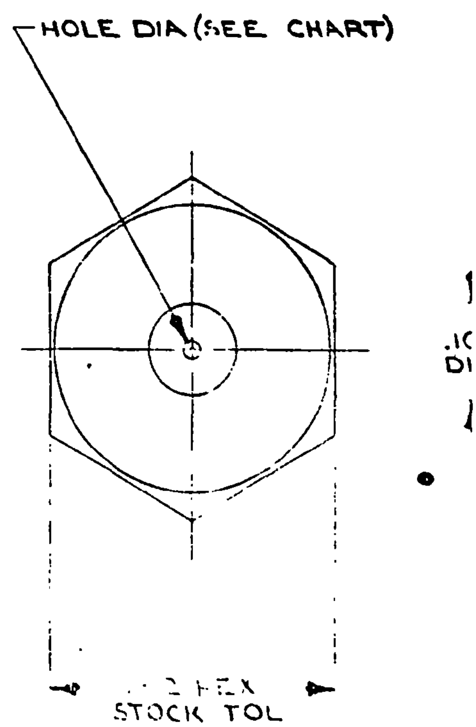
TURNER CORPORATION

ORIFICE SO-0001

PART NO. SO-0001

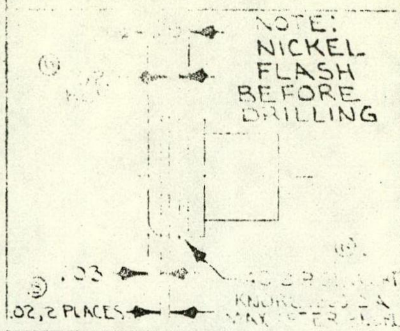
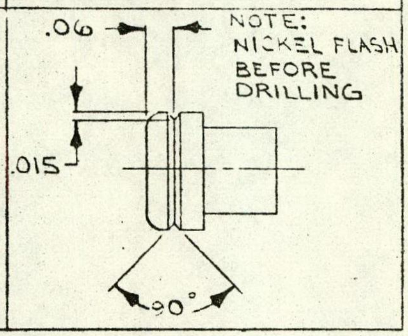
PART NO	DESCRIPTION NO.	HOLE DIA	IDENTIFICATION
LP-3527-R	50-0001-080	.0080 +.0000 −.0005	
LP-3609-R	50-0001-050	.0050 +.0005 −.0000	
LP-3676-R	50-0001-040	.0040 +.0005 −.0000	
LP-3759-R	50-0001-060	.0060 +.0005 −.0000	

PART NO	DESCRIPTION NO	HOLE DIA
LP 4079-R	50-0001-135	.0135 +.000? −.000?

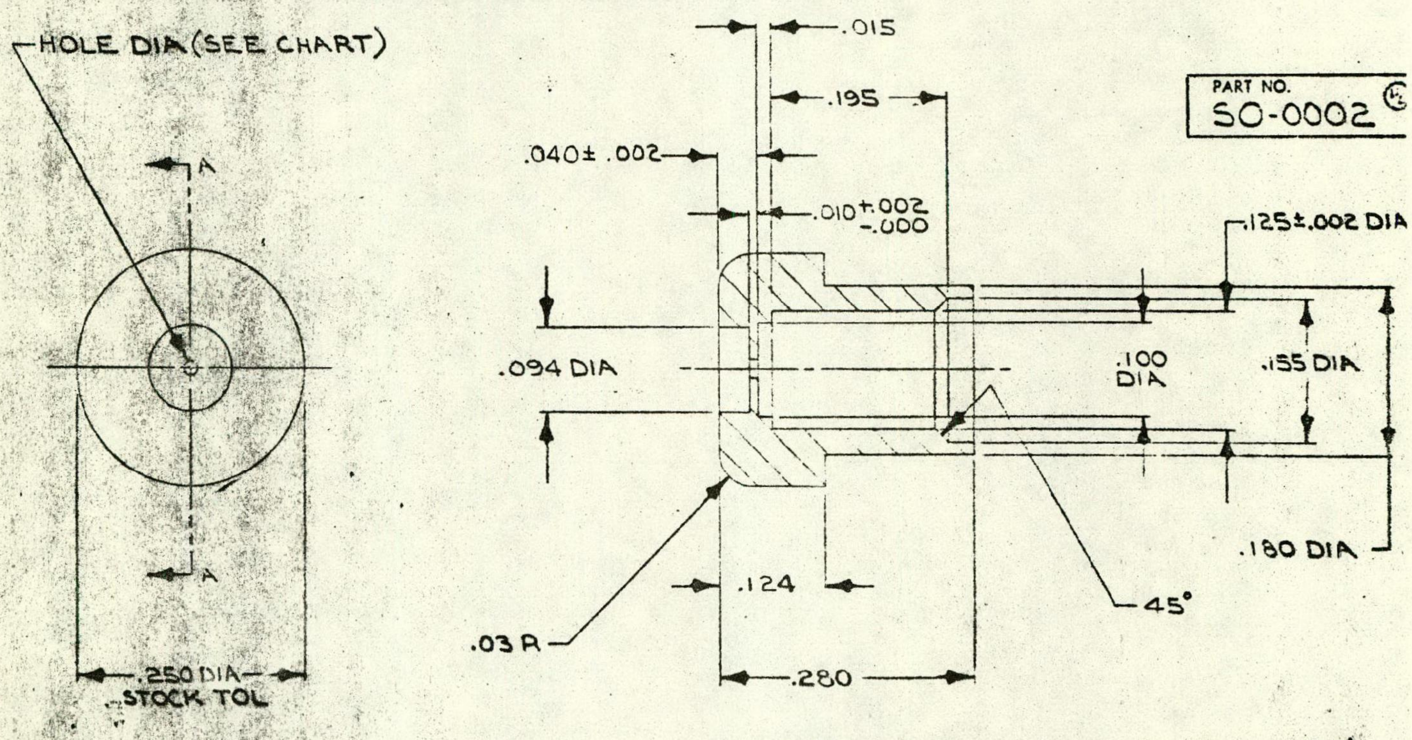


6

CHANGES

PART NO.	DESCRIPTION NO.	HOLE DIA	IDENTIFICATION
LP-4524-R	S0-0002-125	.0125 +.0005 −.0000	
LP-606-R	S0-0002-050	.0050 −.0000 −.0005	PLAIN
LP-3658-R	S0-0002-080	.0080 +.0000 −.0005	PLAIN - NI FLASH BEFORE DRILLING
©	S0-0002-180	.0180 +.0005 −.0000	

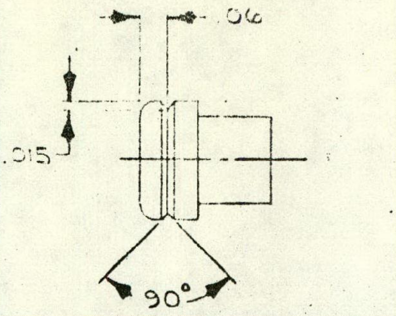
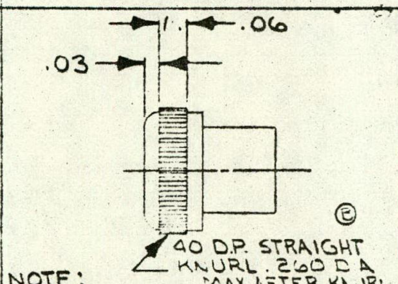
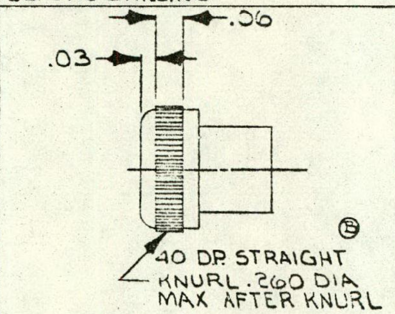
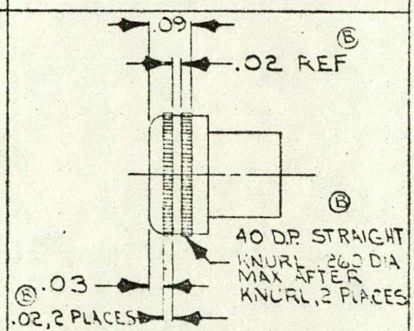
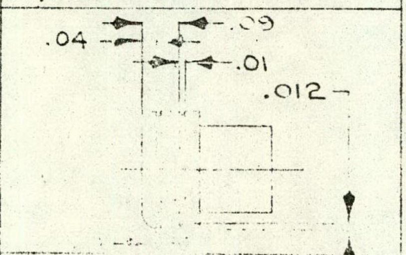
NOTE: THIS ORIFICE WAS USED FOR METERING C_3H_8 UNDER CRITICAL FLOW CONDITIONS. 70 PSIG ≈ 90 ppm FOR TYPICAL CVS.



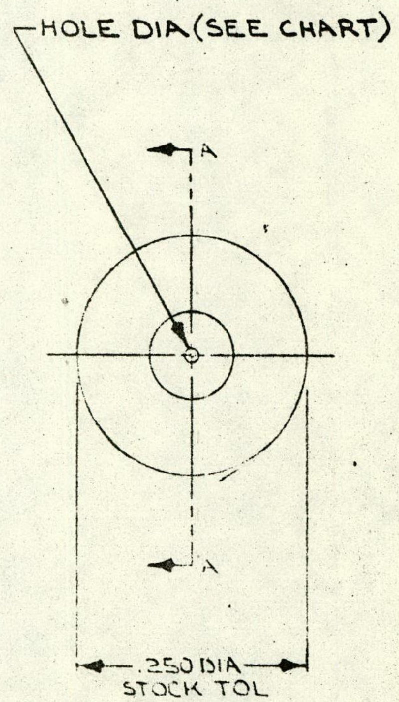
SECTION A-A

61

MAT'L	1/4 DIA RND FCY BRASS ROD NO. 006 113 37
	TURNER CORPORATION
PART NO.	S0-0002

PART NO.	DESCRIPTION NO.	HOLE DIA	IDENTIFICATION
LP-607-R (UL)	SO-0002-060	.0060 +.0000 −.0005	
LP-3761-R (UL)	SO-0002-100	.0100 +.0005 −.0000	 NOTE: NICKEL FLASH BEFORE DRILLING
LP-958-R (UL)	SO-0002-120	.0120 +.0000 −.0005	
LP-3539-R	SO-0002-135	.0135 +.0005 −.0000	
LP-2983-R (UL)	SO-0002-035	.0035 ±.0005	
	SO-0002-055 (D)	.0055 +.0000 −.0005	GROOVES AS ABOVE [illegible] BEFORE DRILLING

PART NO.	DESCRIPTION NO.	HOLE DIA
LP-4524-R	SO-0002-125	.0125 +.0005 −.0000
LP-606-R (UL)	SO-0002-050	.0050 +.0000 −.0005
LP-3658-R	SO-0002-080	.0080 +.0000 −.0005
(C)	SO-0002-180	.0180 +.0005 −.0000



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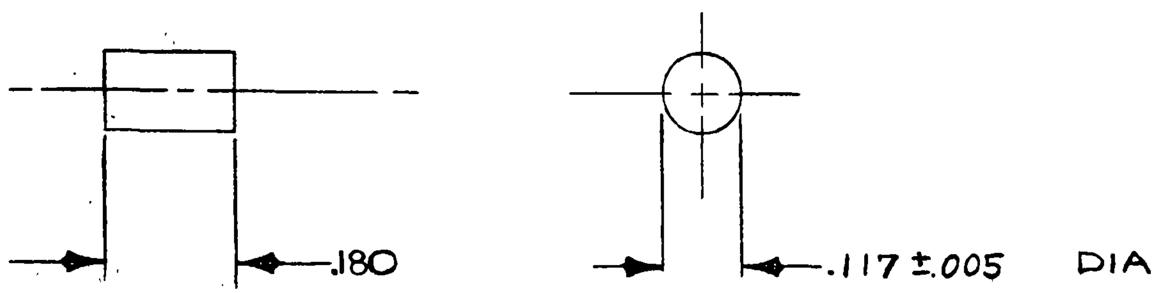
D [illegible] ADDED SO-000-·055
C [illegible] ADDED SO-0002-180
B [illegible] CHANGED KNURL DIMS
A [illegible]

PART NO. LP-3833 (4)



Changes

B 6-25-70 .180 WAS .310

A 3/10/70 .119 ± .003 WAS CHANGED TO .117 ± .005

7-00-[illegible] RELEASE

LP-606-1	LP-607-1	LP-958-1
LP-2833-1	LP-3539-1	LP-3658-1
LP-3761-1	LP-4063-1	
NEXT ASSEM.	NEXT ASSEM.	NEXT ASSEM.

MATL. BRONZE SINTERED POWDER (20 MICRON)

DO NOT SCALE DRAWINGS
STANDARD TOLERANCES
.XX DEC. ± .015
.XXX DEC. ± .005
ANGLE ± 1°

SUPERCEDES 2519X

SCALE 4 = 1

FINISH:

D.L.

DWG GLW 6-26-[illegible]

CHKD [illegible]

APPD [illegible]

TURNER CORPORATION
SYCAMORE, ILL.

PART NAME FILTER

PART NO. LP-3833 (1)

NBS TRACEABLE LFE CALIB.

CEESI

COLORADO
ENGINEERING EXPERIMENT STATION
INC.

OFFICE:
P. O. Box 344
Boulder, Colo. 80302
Phone: 303—443-1344

LABORATORY:
P. O. Box 41
Nunn, Colo. 80648
Phone: 303—897-2340

CALIBRATION OF A MERIAM LAMINAR FLOW ELEMENT
MODEL: 50MC2-4SF   SERIAL NUMBER: Y-72291R
FOR: U.S. ENVIRONMENTAL PROTECTION AGENCY
DATA FILE: EPA1A   DATE: 10 DEC 1976
INLET DIA: 4 INCHES   THROAT DIA: 4 INCHES
TEST GAS: AIR   STD DENSITY= 0.074916 LBM/CU-FT
AT STANDARD CONDITIONS OF 529.69 DEG.R. AND 14.696 PSIA
DIFF: DIFFERENTIAL PRESSURE IN INCHES OF WATER AT 70 DEG F
ACFM: ACTUAL CUBIC FEET PER MINUTE
K FACTOR: ACFM*VISCOSITY/DIFF
REY NO: INLET(PIPE) REYNOLDS NUMBER
SCFM: STANDARD CUBIC FEET PER MINUTE
PRESS: PRESSURE AT INLET TAP IN PSIA
TEMP: INLET TEMPERATURE IN DEGREES RANKINE

THIS # IS CALCULATED FROM CFV DATA (C, P, T)

L	DIFF	ACFM	K FACTOR	REY NO	SCFM	PRESS	TEMP
1	1.215	66.71	5.5225 E-5	26791	67.80	14.693	521.13
2	1.809	99.29	5.5076 E-5	40073	101.20	14.698	519.77
3	2.392	130.38	5.4720 E-5	52612	132.90	14.703	519.91
4	2.975	161.70	5.4583 E-5	65151	164.65	14.696	520.23
5	3.587	194.70	5.4547 E-5	78366	198.15	14.699	520.59
6	4.188	226.13	5.4292 E-5	90860	229.90	14.696	521.04
7	4.816	259.23	5.4160 E-5	104080	263.49	14.703	521.40
8	5.406	290.88	5.4163 E-5	116624	295.40	14.700	521.76
9	6.019	322.67	5.3990 E-5	129238	327.48	14.699	522.03
10	6.658	356.30	5.3905 E-5	142592	361.42	14.696	522.21
11	7.274	388.26	5.3799 E-5	155250	393.71	14.702	522.57
12	7.621	406.01	5.3709 E-5	162263	411.61	14.703	522.75
13	7.627	406.08	5.3680 E-5	162216	411.52	14.698	522.80
14	7.285	388.30	5.3752 E-5	155038	393.38	14.698	522.93
15	5.433	291.04	5.4025 E-5	116178	294.82	14.699	523.02
16	2.990	161.79	5.4561 E-5	64604	163.92	14.699	522.93
17	1.209	66.37	5.5320 E-5	26568	67.36	14.708	522.39
18	0.640	35.37	5.5731 E-5	14148	35.87	14.703	522.48

AVERAGE VALUES FOR ABOVE RESULTS:
P= 14.7 PSIA   DENSITY= 0.076074 LBM/CU-FT
T= 521.77 DEG R   VISCOSITY= 1.0067E-6 LBM/INCH-SEC
Z= 0.99959 COMPRESSIBILITY FACTOR

$°K = 273.16 + °C$

$\mu_{STD} = 1.0185 \times 10^{-6}$ @ 70°F

$(lb_m/\text{in-sec})\ \mu = \left[\frac{145.8 \times °K^{1.5}}{°K + 110.4}\right] .0056 \times 10^{-7}$

APPENDIX 5   DON PAULSELL EPA

CEESI

COLORADO ENGINEERING EXPERIMENT STATION INC.

OFFICE:
P.O. Box 344
Boulder, Colo. 80302
Phone: 303—443-1344

LABORATORY:
P.O. Box 41
Nunn, Colo. 80648
Phone: 303—897-2340

```
MODEL: 50MC2-4SF      SERIAL NUMBER: Y-72291R
DATA FILE: EPA1A      DATE: 10 DEC 1976

X POINTS EXCLUDED FROM AVERAGES.  K(AVE)= 5.4402E-5   %DEV FROM K(AVE):
 L(0) R/1000 MTR READ L(0) -4    -3    -2    -1    0    +1    +2    +3    +4%
                               08642086420864208642024680246802468024680
  18  14.14    0.63951         ................................0........
  17  26.56    1.209       1   ............................0............
  2   40.07    1.8095          ..........................0..............
  3   52.61    2.3919          .......................0.................
  16  64.6     2.9904      4   .....................00..................
  5   78.36    3.5869          .....................0...................
  6   90.86    4.1884          ...................0.....................
  7   104.08   4.8159          ..................0......................
  15  116.17   5.4334      8   .................00......................
  9   129.23   6.0188          ................0........................
  10  142.59   6.6583          ...............0.........................
  14  155.03   7.2849      11  ..............0..........................
  13  162.21   7.6271      12  .............00..........................

SCALE,? 4
LO: 1.41 E+4  R  6.35 E+4    K= 5.52143 E-5   K/K(AVE)= 1.01493
STD DEV= 0.37 E-6            % STD DEV= 0.666  BASED ON  5 DATA PTS
MAX DEV= 0.52 E-6            % MAX DEV= 0.936  AT L=18   CHAUV= 1.6
MD: 6.35 E+4  R  1.13 E+5    K= 5.44286 E-5   K/K(AVE)= 1.00049
STD DEV= 0.19 E-6            % STD DEV= 0.351  BASED ON  5 DATA PTS
MAX DEV= -.27 E-6            % MAX DEV=-0.494  AT L= 7   CHAUV= 1.597
HI: 1.13 E+5  R  1.62 E+5    K= 5.38779 E-5   K/K(AVE)= 0.99036
STD DEV= 0.17 E-6            % STD DEV= 0.318  BASED ON  8 DATA PTS
MAX DEV= 0.29 E-6            % MAX DEV= 0.529  AT L= 8   CHAUV= 1.558

R(AVE)= 94591             K(AVE)= 5.4402E-5

R(LO)= 32038.   R(MD)= 80612.   R(HI)= 142420.

K = A + B*R + C*R*R
A= 5.5903E-5    B=-2.3589E-11    C= 6.5817E-17

K = X + Y*(MTR READ) + Z*(MTR READ)*(MTR READ)
X= 5.5887E-5    Y=-5.0786E-7    Z= 3.0976E-8
BASED ON ABOVE TEST DATA (P,T,GAS)
  AND ASSUMING K CORRELATES WITH MTR READ

THIS CALIBRATION IS TRACEABLE TO NBS.
THE FLOW MEASUREMENT ACCURACY IS ESTIMATED TO BE: ± 0.5% w. SEIDL
COLO ENGINEERING EXPERIMENT STATION INC,BX 41,NUNN CO 80648
```

CALIBRATION DATA FOR LFE # Y-7291R
12/10/76

1 DATA POINT	2 SCFM[1]	3 PABS	4 TABS	5 ACFM[2]	6 VISCOSITY $\mu \times 10^6$ [3]	7 $K \times 10^5$ [4]	8 ΔP ("H_2O)	9 CFM[5]	R#
	67.80	14.693	521.13	66.71	1.0057	5.5225	1.215	65.8736	26791
	101.20	14.698	519.77	99.29	1.0037	5.5076	1.809	97.8464	40073
	132.90	14.703	519.91	130.38	1.0039	5.4720	2.392	128.5112	52612
	164.65	14.696	520.23	161.70	1.0044	5.4583	2.975	159.4585	65151
	198.15	14.699	520.59	194.70	1.0049	5.4547	3.587	192.1042	78366
	229.90	14.696	521.04	226.13	1.0056	5.4292	4.188	223.2645	90860
	263.49	14.703	521.40	259.23	1.0061	5.4160	4.816	256.0826	104080
	295.40	14.700	521.76	290.88	1.0067	5.4163	5.406	287.5003	116624
	327.48	14.699	522.03	322.67	1.0071	5.3990	6.019	319.0512	[illegible]
	361.42	14.696	522.21	356.30	1.0074	5.3905	6.653	352.3932	142592
	393.71	14.702	522.57	388.26	1.0079	5.3799	7.274	384.2135	155250
	411.61	14.703	522.75	406.01	1.0082	5.3709	7.621	401.8559	162263
	411.52	14.693	522.80	406.08	1.0082	5.3680	7.627	401.9850	162216
	393.38	14.698	522.93	388.30	1.0084	5.3752	7.285	384.4584	155038
	294.82	14.699	523.02	291.04	1.0086	5.4025	5.433	288.1991	116178
	163.92	14.699	522.93	161.79	1.0084	5.4561	2.990	160.1893	64604
	67.36	14.708	522.39	66.37	1.0076	5.5320	1.209	65.6607	26568
	35.87	14.703	522.48	35.37	1.0078	5.5731	0.640	34.9467	14148

DATA REDUCTION OF CEESI SUPPLIED DATA TO GET INPUT FOR $[CFM = A \cdot \Delta P + B \cdot \Delta P^2]$

1. @ 529.69 °R 14.696 PSI
2. $ACFM = SCFM \cdot \frac{14.696}{PABS} \cdot \frac{TABS}{529.69}$
3. $\mu = \left[\frac{145.8 \times {}^\circ K^{1.5}}{{}^\circ K + 110.4} \right] \times .0056 \times 10^{-7}$
4. $K = ACFM \cdot \mu / \Delta P$
5. $CFM = ACFM \cdot \frac{\mu}{\mu_{STD} @ 70°}$ $\mu_{STD} = 1.0185 \times 10^{-6}$

**** PROCESSED: 13:05:40 07-11-77

*** ANALYZER CALIBRATION CURVE ANALYSIS ***

END CALIB AT TIME : 0: 0	ANALYZER VENDOR :	SAMPLE FLOW RATE : 0.0	VALID DEFL. UPPER LIMIT : 110.000
CALIBRATION DATE : 0- 0- 0	INSTRUMENT NAME :	MONITOR SET POINT : 0.0	VALID DEFL. LOWER LIMIT : -10.000
TEST SITE NUMBER :	EPA DECAL ID NO :	ZERO GAIN SETTING : 0.0	RANGE CHANGE UPPER LIMIT : 100.000
GAS ANALYZED :PROPANE	SIGNAL LEAD :	SPAN GAIN SETTING : 0.0	RANGE CHANGE LOWER LIMIT : 20.000
DILUENT GAS :OZONE	RANGE F RANGE :	TUN READING : 0.0	FULL-SCALE (100%) DEFL. : 100.000
CONCENTRATION UNIT: PPM	USAGE :	FID AIR PRESSURE : 0.0	FULL-SCALE (100%) VOLTAGE: 0.0
STANDARD LAB RANGE: 18	CALB GAS SOURCE :	FID FUEL PRESSURE : 0.0	FULL-SCALE (100%) CONC. : 522.9
OPERATOR ID NO : 22087	BLENDER DECAL ID :	FID SAMP PRESSURE : 0.0	RECORDER TYPE :

FILE COMMENT : NOTE: X AXIS IS IN P*10 C
OPERATOR COMMENT : CEM VS P FOR LEE # Y-772910 : 12/10/76

CYLINDER NUMBER	BLENDER METER READINGS SPAN	BLENDER METER READINGS DILUENT	BLEND RATIO	CONCENTRATIONS CYLINDER (BLENDED)	CONCENTRATIONS CALCULATED	ANALYZER SIGNAL MEASURED X M	ANALYZER SIGNAL CORRECTED X C	CALIBRATION DATA POINT	CURVE FIT DEVIATIONS % POINT	CURVE FIT DEVIATIONS % FULL-SCALE	CURVE FIT DEVIATIONS % FROM LAST CALIBRATION
	X			0.0							
		X		0.0							
	0.0	0.0	0.0	65.87	65.48	12.150	12.150		0.0	0.0	0.0
	0.0	0.0	0.0	97.35	97.30	18.090	18.090		0.0	0.0	0.0
	0.0	0.0	0.0	128.51	128.40	23.920	23.920	X	-0.084	-0.021	0.0
	0.0	0.0	0.0	159.46	159.33	29.750	29.750	X	-0.048	-0.015	0.0
	0.0	0.0	0.0	192.10	191.77	35.870	35.870	X	-0.175	-0.064	0.0
	0.0	0.0	0.0	223.26	223.44	41.880	41.880	X	0.078	0.033	0.0
	0.0	0.0	0.0	256.08	255.34	48.160	48.160	X	0.121	0.059	0.0
	0.0	0.0	0.0	287.50	287.22	54.060	54.060	X	-0.099	-0.054	0.0
	0.0	0.0	0.0	319.05	319.11	60.190	60.190	X	0.020	0.012	0.0
	0.0	0.0	0.0	352.40	352.22	66.580	66.580	X	-0.052	-0.035	0.0
	0.0	0.0	0.0	384.21	383.98	72.740	72.740	X	-0.060	-0.044	0.0
	0.0	0.0	0.0	401.99	401.32	76.210	76.210	X	-0.017	-0.013	0.0
	0.0	0.0	0.0	401.99	402.13	76.270	76.270	X	0.035	0.027	0.0
	0.0	0.0	0.0	384.46	384.55	72.850	72.850	X	0.024	0.017	0.0
	0.0	0.0	0.0	288.20	288.63	54.330	54.330	X	0.148	0.082	0.0
	0.0	0.0	0.0	160.19	160.18	29.900	29.900	X	-0.008	-0.002	0.0
	0.0	0.0	0.0	65.66	65.16	12.090	12.090		0.0	0.0	0.0
	0.0	0.0	0.0	35.00	34.56	6.400	6.400		0.0	0.0	0.0

NONLINEARITY = -0.9 PERCENT

AVERAGE DEVIATION	% POINT	% FULL-SCALE	% FROM LAST CALIBRATION
	0.069	0.034	0.0

10.

**** PROCESSED: 13:05:40 07-11-77

```
*********************************************
*********************************************
***                                       ***
*** ANALYZER CALIBRATION CURVE ANALYSIS   ***
***                                       ***
*********************************************
*********************************************
```

END CALIB AT TIME : 0: 0	ANALYZER VENDOR	:	ZERO SPAN TYPE	:	1
CALIBRATION DATE : 0- 0- 0	INSTRUMENT NAME	:	CURVE FORM	:	1
TEST SITE NUMBER :	EPA DECAL ID NO	:	DEGREE FIT	:	2
GAS ANALYZED :PROPANE	SIGNAL LEAD	:	WEIGHTING FACTOR	:	1
FULL-SCALE CONC : 522.9	HARDWARE RANGE	:			
CONCENTRATION UNIT: PPM	USAGE	:			
STANDARD LAB RANGE: 18	OPERATOR ID NO	: 22087			

EQUATIONS AND COEFFICIENTS
****

$X_C = X$:

$$(A5*X_C^4 + A4*X_C^3 + A3*X_C^2 + A2*X_C + A1) = \text{PPM PROPANE/OZONE}$$

CALIBRATION P(BARO) = 0.0

A1 = 0.0
A2 = 0.5411711E+01
A3 = -0.1826475E-02
A4 = 0.0
A5 = 0.0

CALIBRATION TABLE PERCENT FULL-SCALE CHART DEFLECTION VS PPM PROPANE/OZONE

0.	0.0																		
1.	5.41	11.	59.31	21.	112.84	31.	166.11	41.	21[illegible].81	51.	271.25	61.	323.32	71.	375.02	81.	426.37	91.	477.34
2.	10.82	12.	64.68	22.	118.17	32.	171.30	42.	22[illegible].07	52.	276.47	62.	328.51	72.	380.17	82.	431.48	92.	482.42
3.	16.22	13.	70.04	23.	12[illegible].50	33.	176.60	43.	22[illegible].33	53.	281.69	63.	333.69	73.	385.32	83.	436.59	93.	487.49
4.	21.62	14.	75.41	24.	12[illegible].83	34.	181.89	44.	23[illegible].58	54.	286.91	64.	338.87	74.	390.46	84.	441.70	94.	492.56
5.	27.01	15.	80.76	25.	134.15	35.	187.17	45.	23[illegible].33	55.	292.12	65.	344.04	75.	395.60	85.	446.80	95.	497.63
6.	32.40	16.	86.12	26.	139.47	36.	192.45	46.	24[illegible].07	56.	297.33	66.	349.22	76.	400.74	86.	451.90	96.	502.69
7.	37.79	17.	91.47	27.	144.78	37.	197.73	47.	25[illegible].32	57.	302.53	67.	354.39	77.	405.87	87.	456.99	97.	507.75
8.	43.18	18.	96.82	28.	1[illegible].10	38.	203.01	48.	25[illegible].55	58.	307.73	68.	359.55	78.	411.00	88.	462.09	98.	512.81
9.	48.56	19.	102.16	29.	155.40	39.	208.28	49.	260.79	59.	312.93	69.	364.71	79.	416.13	89.	467.17	99.	517.86
10.	53.93	20.	107.50	30.	16[illegible].71	40.	213.55	50.	266.02	60.	318.13	70.	369.87	80.	421.25	90.	472.26	100.	522.91

QUALITY CONTROL COMMENTS
****

****** CURVE NOT STORED ON FILE

89

COLORADO ENGINEERING EXPERIMENT STATION, INC.
P. O. Box 344
Boulder, Colorado 80302

Date: December 15, 1976

This is to certify that the instrumentation used in the calibration of Meriam Laminar Flow Element
Model No. 50MC2-4SF Serial No. Y-72291R
is traceable to the National Bureau of Standards.

Walter F. Seidl
President (Acting)

CEESI

COLORADO ENGINEERING EXPERIMENT STATION INC.

OFFICE:
P. O. Box 344
Boulder, Colo. 80302
Phone: 303—443-1344

LABORATORY:
P. O. Box 41
Nunn, Colo. 80648
Phone: 303—897-2340

Date: December 15, 1976

This is to certify that the accuracy of the calibration on Meriam Laminar Flow Element

Model No. 50MC2-4SF Serial No. Y-72291R

is Within plus or minus 0.4 percent of reading.

Walter F. Seidl

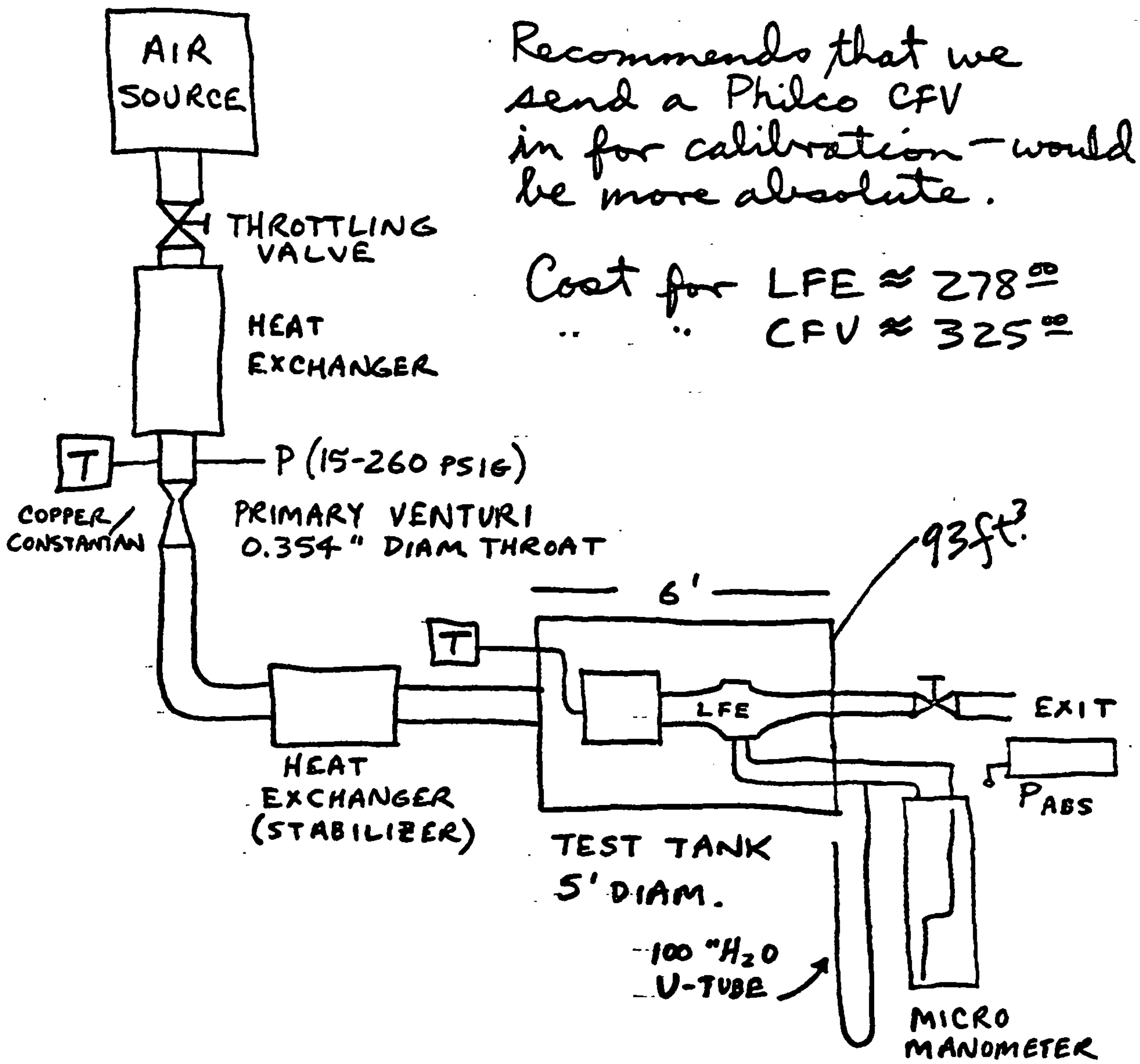
President (Acting)

WALT SEIDL
303-534-7535   FTS 327-0111

STEVE CALDWELL
LAB. TECHNICIAN
FTS 8-327-0111

CEESI
303-897-2340

TEST SETUP FOR LFE CALIB.



Recommends that we send a Philco CFV in for calibration — would be more absolute.

Cost for LFE ≈ 278.00
" " CFV ≈ 325.00

15.

CEESI

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LABORATORY:
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Nunn, Colo. 80648
Phone: 303—897-2340

February 7, 1974

MEMO:

To our customers

Re: Shipping Methods, in order of preference

1. United Parcel Service (where available)
   Address: Colorado Engineering Experiment Station
   Missile Site
   Nunn, Colorado
   Limitations: 100 lb. per day
   Insurance: $5,000.00 max.
   Receipt is provided

2. U. S. Postal Service (parcel post)
   Address: Colorado Engineering Experiment Station
   P. O. Box 41
   Nunn, Colorado 80643
   Limitations: 70 lb.
   Length & Girth = 100" max.
   Insurance: $200.00 max.
   Receipt is provided if insured. If not insured, a Certificate of Mailing costs 5 cents.

3. Bus Package Express
   Address: Colorado Engineering Experiment Station
   Fort Collins, Colorado
   On arrival phone: 484-9365
   Limitations: 100 lb. / package
   5 packages / shipment
   Length & Width & Height = 141" max.
   Height = 60" max.
   Insurance: $250.00 max.
   Receipt is provided.

MEMO: To our customers
February 7, 1974
Page 2

3. Motor Freight (TWX)
Address: Colorado Engineering Experiment Station
Missile Site
Nunn, Colorado
Limitations: Check that they are not on strike at Denver. (Alternate truck line from Denver to our site: Miller Bros., Inc.)

5. Air Freight
To Denver: Motor freight to our site (see above)
To Cheyene: We can arrange pick up.
Limitations to Cheyene:
Frontier - Weight - 200 lb.
Width 28", Length 40", Height 48"
Western - Weight 250 lb.
500 lb with special arrangements.

Max. - Width	Height	Length
12"	10"	186"
24"	25"	157"
34"	20"	124"
30"	45"	36"

Insurance: No limit
Receipt is provided

6. REA Express
Address: Colorado Engineering Experiment Station
Loveland, Colorado
On arrival, phone: 897-2340
or: 434-9365
Limitations: None
Insurance: No limit

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Phone: 303—897-2340

LIBRATION OF A MERIAM LAMINAR FLOW ELEMENT
DEL: 50MC2-8F   S/N: F62502TR   EPA TAG: 092015
R: U.S. ENVIRONMENTAL PROTECTION AGENCY   ORDER: CD-7-20876-A
TA FILE: EPA5   DATE: 18 AUGUST 1977
LET DIA: 6 INCHES   THROAT DIA: 12 INCHES
ST GAS: AIR   STD DENSITY= 0.074916 LBM/CU-FT
AT STANDARD CONDITIONS OF 529.69 DEG R, AND 14.696 PSIA
F: DIFFERENTIAL PRESSURE IN INCHES OF WATER AT 68 DEG F
M: ACTUAL CUBIC FEET PER MINUTE
FACTOR: ACFM*VISCOSITY/DIFF
NO: INLET(PIPE) REYNOLDS NUMBER
FM: STANDARD CUBIC FEET PER MINUTE
SS: PRESSURE AT INLET TAP IN PSIA
P: INLET TEMPERATURE IN DEGREES RANKINE

	DIFF	ACFM	K FACTOR	REY NO	SCFM	PRESS	TEMP
1	7.625	2017.63	2.7072 E-4	519658	2006.61	14.701	532.79
2	7.814	2064.82	2.6961 E-4	535063	2060.40	14.698	530.89
3	7.633	2019.37	2.7059 E-4	520135	2007.87	14.692	532.59
4	7.444	1973.03	2.7107 E-4	508556	1962.88	14.698	532.49
5	6.958	1849.40	2.7148 E-4	477947	1842.33	14.692	531.59
6	6.209	1655.89	2.7277 E-4	426565	1646.66	14.694	532.59
7	5.399	1443.24	2.7336 E-4	372000	1435.82	14.698	532.49
8	6.179	1649.66	2.7231 E-4	427611	1646.15	14.692	530.69
9	4.573	1231.25	2.7520 E-4	317599	1225.31	14.694	532.19
10	3.814	1029.03	2.7608 E-4	264819	1022.72	14.694	532.89
11	3.046	825.56	2.7729 E-4	212598	820.81	14.694	532.69
12	3.800	1027.02	2.7639 E-4	264652	1021.48	14.694	532.49
13	2.274	616.41	2.7724 E-4	158716	612.78	14.692	532.69
14	1.512	409.31	2.7704 E-4	105334	406.79	14.694	532.89
15	1.374	372.54	2.7756 E-4	95690	369.82	14.691	533.39
16	1.148	312.93	2.7863 E-4	80667	311.31	14.694	532.39
17	0.933	254.29	2.7852 E-4	65624	253.15	14.696	532.09
18	0.719	196.08	2.7856 E-4	50600	195.16	14.691	531.99
19	0.934	254.24	2.7820 E-4	65637	253.12	14.692	531.89

AVERAGE VALUES FOR ABOVE RESULTS:
P= 14.694 PSIA   DENSITY= 0.07454 LBM/CU-FT
T= 532.3 DEG R   VISCOSITY= 1.0224E-6 LBM/INCH-SEC
Z= 0.99965 COMPRESSIBILITY FACTOR

COLORADO ENGINEERING EXPERIMENT STATION INC.

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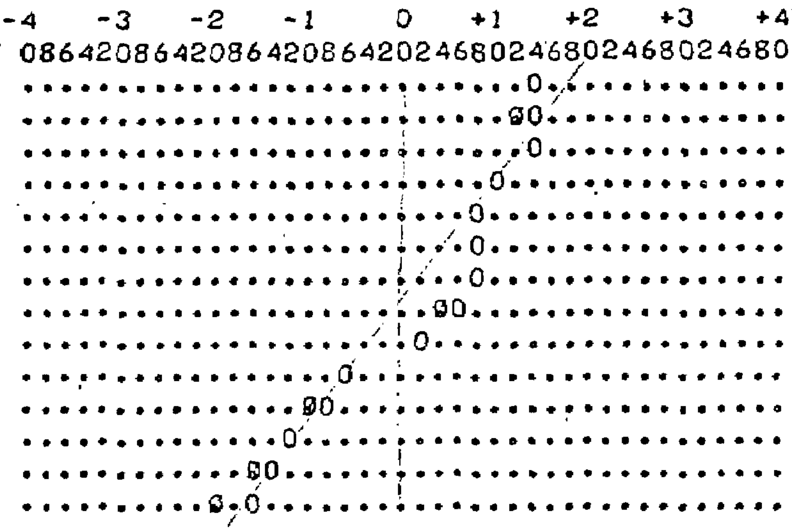
Phone: 303—897-2340

MODEL: 50MC2-8F S/N: F62502TR EPA TAG: 092015
DATA FILE: EPA5 DATE: 18 AUGUST 1977

0 POINTS EXCLUDED FROM AVERAGES. K(AVE)= 2.7488E-4 %DEV FROM K(AVE))

L(0)	R/1000	MTR READ	L(0)
18	50.59	0.71933	
17	65.62	0.93317	19
16	80.66	1.1484	
15	95.68	1.3744	
14	105.33	1.5118	
13	158.71	2.2744	
11	212.59	3.0456	
12	264.65	3.8	10
9	317.59	4.5734	
7	372	5.3993	
6	426.56	6.2091	8
5	477.94	6.9575	
4	508.55	7.4436	1
3	520.13	7.633	2



SCALE,? 4
LO: 5.06 E+4 R 2.12 E+5 K= 2.77965 E-4 K/K(AVE)= 1.01124
STD DEV= 0.67 E-6 % STD DEV= 0.242 BASED ON 7 DATA PTS
MAX DEV= -.93 E-6 % MAX DEV=-0.334 AT L=14 CHAUV= 2.35
MD: 2.12 E+5 R 3.74 E+5 K= 2.75666 E-4 K/K(AVE)= 1.00287
STD DEV= 0.15 E-5 % STD DEV= 0.540 BASED ON 5 DATA PTS
MAX DEV= -.23 E-5 % MAX DEV=-0.836 AT L= 7 CHAUV= 1.222
HI: 3.74 E+5 R 5.35 E+5 K= 2.71224 E-4 K/K(AVE)= 0.98671
STD DEV= 0.11 E-5 % STD DEV= 0.396 BASED ON 7 DATA PTS
MAX DEV= -.16 E-5 % MAX DEV=-0.594 AT L= 2 CHAUV= 1.882

R(AVE)= 287866 K(AVE)= 2.7488E-4

R(LO)= 88895. R(MD)= 286330. R(HI)= 487930.

K = A + B*R + C*R*R
A= 2.7834E-4 B=-1.87E-12 C=-2.6043E-17

K = X + Y*(MTR READ) + Z*(MTR READ)*(MTR READ)
X= 2.7838E-4 Y=-1.8012E-7 Z=-1.1576E-7
BASED ON ABOVE TEST DATA (P,T,GAS)
AND ASSUMING K CORRELATES WITH MTR READ

THIS CALIBRATION IS TRACEABLE TO NBS.
THE FLOW MEASUREMENT ACCURACY IS ESTIMATED TO BE: ±0.5% of scale
COLO ENGINEERING EXPERIMENT STATION INC,BX 41,NUNN CO 80648

COLORADO
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```
DATA? EPA5OUT
NUMBER OF PØINTS? 19

 MEAN VALUE OF X = 287868.
 MEAN VALUE ØF Y = 2.74875E-4
 STD ERRØR ØF Y = 3.17808E-6

POLYFIT OF DEGREE 2 INDEX ØF DETERM = 0.983963    WHAT NEXT? 2

TERM   CØEFFICIENT

 0     2.78637E-4
 1    -4.29867E-12
 2    -2.21441E-17
```

X ACTUAL	Y-ACTUAL	Y-CALC	DIFF	PCT-DIFF
[illegible]19658	2.70722E-4	2.70424E-4	2.98425E-7	0.11
[illegible]35060	2.6961E-4	2.69998E-4	-3.87643E-7	-0.144
5[illegible]20140	2.7059E-4	2.7041E-4	1.79595E-7	0.066
5[illegible]8560	2.7107E-4	2.70724E-4	3.46026E-7	0.128
[illegible]77950	2.7148E-4	2.71524E-4	-4.42407E-8	-0.016
[illegible]26570	2.7277E-4	2.72774E-4	-4.23702E-9	-0.002
[illegible]2000	2.7336E-4	2.73974E-4	-6.13808E-7	-0.224
[illegible]27610	2.7231E-4	2.7275E-4	-4.40094E-7	-0.161
[illegible]17600	2.752E-4	2.75038E-4	1.61621E-7	0.059
[illegible]4820	2.7608E-4	2.75946E-4	1.34028E-7	0.049
[illegible]2600	2.7729E-4	2.76723E-4	5.67479E-7	0.205
2[illegible]4650	2.7639E-4	2.75949E-4	4.41304E-7	0.16
1[illegible]8720	2.7724E-4	2.77397E-4	-1.57166E-7	-0.057
1[illegible]5330	2.7704E-4	2.77939E-4	-8.98853E-7	-0.323
9[illegible]690	2.7756E-4	2.78023E-4	-4.63202E-7	-0.167
[illegible]0667	2.7863E-4	2.78146E-4	4.83548E-7	0.174
[illegible]624	2.7852E-4	2.7826E-4	2.60155E-7	0.093
5[illegible]600	2.7856E-4	2.78363E-4	1.96902E-7	0.071
[illegible]637	2.782E-4	2.7826E-4	-5.97522E-8	-0.021

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STD ERRØR ØF ESTIMATE FØR Y = 0.00153207
```

COLORADO
ENGINEERING EXPERIMENT STATION
INC.

LAMINAR ELEMENT FLOW TABLE
MODEL: 50MC2-8F S/N: F62502TR EPA TAG: 092015
FOR: U.S. ENVIRONMENTAL PROTECTION AGENCY ORDER: CD-7-20876-A
CALIBRATION DATA FILE: EPA5 DATE: 18 AUGUST 1977
K FACTORS BASED ON LEAST-SQUARES FIT TO CALIBRATION DATA
FLOWRATES CORRECTED TO 14.696 PSIA AND 70 DEGREES FAHRENHEIT
DIFF: DIFFERENTIAL PRESSURE IN INCHES OF WATER AT 68 DEG F
ACFM: FLOWRATE IN ACTUAL CUBIC FEET PER MINUTE
K FACTOR: ACFM*VISCOSITY/DIFF
REY NO: INLET (PIPE) REYNOLDS NUMBER
SCFM: FLOWRATE IN STANDARD CUBIC FEET PER MINUTE
STANDARD CONDITIONS: 14.696 PSIA AND 70 DEGREES FAHRENHEIT

DIFF	ACFM	K FACTOR	REY NO	SCFM
0.750	204.96	2.7834 E-4	53320	204.96
1.000	273.16	2.7822 E-4	71061	273.16
1.250	341.28	2.7808 E-4	88781	341.28
1.500	409.32	2.7793 E-4	106479	409.31
1.750	477.25	2.7776 E-4	124151	477.24
2.000	545.07	2.7758 E-4	141795	545.07
2.250	612.78	2.7739 E-4	159408	612.78
2.500	680.36	2.7718 E-4	176988	680.35
2.750	747.80	2.7696 E-4	194533	747.80
3.000	815.10	2.7673 E-4	212039	815.09
3.250	882.24	2.7648 E-4	229504	882.23
3.500	949.22	2.7623 E-4	246926	949.21
3.750	1016.02	2.7595 E-4	264303	1016.01
4.000	1082.64	2.7567 E-4	281633	1082.63
4.250	1149.07	2.7537 E-4	298912	1149.05
4.500	1215.29	2.7506 E-4	316140	1215.28
4.750	1281.31	2.7474 E-4	333313	1281.30
5.000	1347.12	2.7441 E-4	350429	1347.10
5.250	1412.70	2.7407 E-4	367487	1412.68
5.500	1478.05	2.7371 E-4	384500	1478.03
5.750	1543.15	2.7334 E-4	401437	1543.14
6.000	1608.02	2.7296 E-4	418311	1608.00
6.250	1672.62	2.7257 E-4	435118	1672.61
6.500	1736.97	2.7217 E-4	451858	1736.95
6.750	1801.05	2.7176 E-4	468528	1801.03
7.000	1864.86	2.7134 E-4	485127	1864.84
7.250	1928.38	2.7091 E-4	501653	1928.36
7.500	1991.62	2.7047 E-4	518104	1991.60
7.750	2054.57	2.7001 E-4	534480	2054.55
8.000	2117.22	2.6955 E-4	550778	2117.20

DYNAMOMETER SYSTEM

	QC CHECK	TECHNIQUE	FREQUENCY	ACCURACY
1.	Driving Aid Calibration	Roll Revolution Count	30 Days	± 0.1 mph
2.	Tachometer Calibration	Digital Counter	BiMonthly	± 10 rpm
3.	Driving Aid Check	Roll Revolution Count	Daily	± 0.1%
4.	Frictional HP-Road Load HP Check	Coastdown	Weekly	± 0.5 HP

APPENDIX 6a BRUCE GARDNER, FORD

QUICK COASTDOWNS

AFTER COMPLETE DYNAMOMETER CALIBRATION AND COASTDOWNS

DATE	IND HP @ 50	TIME	ABSORBED HP
2-9-75	9.8 HP	13.8 sec	19.80 HP
		13.8	19.80
		13.8	19.80
2-10-75	9.8	13.4	20.39
		13.6	20.09
		13.8	19.80
		14.0	19.52
		14.0	19.52
		14.0	19.52
2-11-75	9.9	13.6	20.09
		13.6	20.09
		13.8	19.80
		13.8	19.80
		13.8	19.80
2-12-75	9.8	13.6	20.09
		13.8	19.80
		13.8	19.80
		13.8	19.80
2-13-76	9.8	13.6	20.09
		13.8	19.80
		13.8	19.80
		13.8	19.80

QUICK COASTDOWNS

CAR #258 ROLLS #27

COASTDOWN WITH VEHICLE ON ROLLS AFTER TEN MINUTE WARM-UP

4500 LB., AUTO ROAD LOAD

DATE	IND HP @ 50	TIME	ABSORBED HP
2-2-75	9.8	13.8	19.80
		13.8	19.80
		13.8	19.80
		14.0	19.52
		14.0	19.52
		14.0	19.52
2-3-75	9.8	13.8	19.80
		13.8	19.80
		14.0	19.52
		14.0	19.52
		14.0	19.52
2-4-75	9.8	13.6	20.09
		13.8	19.80
		13.8	19.80
		13.8	19.80
2-5-75	9.9	13.2	20.70
		13.4	20.39
		13.4	20.39
		13.6	20.09
		13.8	19.80
		13.6	20.09
		13.8	19.80
		13.8	19.80
		13.8	19.80
2-6-75	10.0	13.8	19.80
		13.8	19.80
		13.8	19.80
		13.8	19.80

APPENDIX 6b F. JOHNSON, CHRYSLER

DYNAMOMETER SYSTEM

General

- Operate in the Automatic Mode
- Speed and Horsepower Calibration per Federal Register
- Individual Interia WeighT ~~Setting~~ Calibrations
- Computerized Least Squares Curve FiT
- Computer Program Generates Actual vs Indicated H.P.
- Thumbwheel Switches for Setting H.P.
- Dynamometer Uniformity
    - Roll Spacing - 17.25 inches
    - Machined Rolls
    - Laser Beam AlignmenT
    - Solid Bearing SupporTs
    - Uniform Circumference

Calibration

- Driver's Aid Linearity Checks
- Full Dynamometer Speed and Horsepower Verification - 30 Days
- [redacted] H.P. Checks Before Test
- Dynamometer Verification Unit
- 160 Pulse/rev. Optical Encoder
- Computer Data Acquisition During Testing
- Back-up Display Devices
- Line - Synchronized STroboscope Speed Calibration
- Dynamometer Coastdown Vehicle

T.L.S - 10/5/77
G.M.P.G.

APPENDIX 6C

EPA IV-1

"DVU" MONITORING

A. IW ENGAGEMENT - MICROSWITCH DECODER/ALARM

B. SPEED (RR) AND TORQUE

C. HP READOUT @ 50 MPH (FR)
   - MAGNETIC P/U ON TACH DRIVE GEAR (24 TEETH) IS USED TO TRIGGER Hp.

D. TWO ROLL REVS COUNTERS

EPA IV - 2

ROLL REVS DATA

	$\bar{X}$	SIGMA	95% C.L.	MILES	%Δ
N= 812 BAG 1	8407.	77.7	1.8%	3.6058	.4
BAG 2	9116.	105.5	2.3%	3.9010	1.1
BAG 3	8409.	78.6	1.9%	3.6067	.4
HWFE N=691	24004.	187.2	1.6%	10.295	.5

QC FLAG = AVERAGE RR ± 2%

REAR ROLL ENCODER = 320 P/R
(160 P/R DRIVEN @ 2:1 ROLL SPEED)
DVU DIVIDES BY 32 TO COUNT 10 P/R

APPENDIX 6 D

DON PAULSELL-EPA

VEHICLE CROSS CHECK LIMITS

	HC	CO	NOx	CO_2
EMISSION LEVEL GRAMS/MILE	1.40	8.5	3.3	600
MAXIMUM PERCENT VARIATION	5.0%	10.0%	8.0%	3.0%

	HC	CO	NOx	CO_2
EMISSION LEVEL GRAMS/MILE	0.5	4.0	2.3	670
MAXIMUM PERCENT VARIATION	10.0%	15.0%	10.0%	3.0%

EXPLANATION OF TERMS USED IN CROSS CHECK SUMMARY

MEAN: SUM OF DATA ENTRIES DIVIDED BY THE NUMBER OF ENTRIES GIVES AVERAGE VALUE OF DATA

$$\text{MEAN} = \frac{\Sigma X_i}{N} = \bar{X}$$

STANDARD DEVIATION: GIVES THE AVERAGE DIFFERENCE BETWEEN THE INDIVIDUAL DATA ENTRIES AND THE MEAN.

COMPUTED BY SUBTRACTING A DATA ENTRY FROM THE MEAN AND SQUARING THE DIFFERENCE. THE SQUARED TERMS ARE ADDED TOGETHER AND THAT TOTAL IS DIVIDED BY THE NUMBER OF ENTRIES MINUS ONE. THE SQUARE ROOT OF THAT ANSWER IS THE S.D.

$$\text{S.D.} = \sqrt{\frac{\sum_{i=1}^{N} (X_i - \bar{X})^2}{N-1}}$$

VARIANCE: IS THE SQUARE OF THE STANDARD DEVIATION

$$\text{VAR.} = \frac{\sum_{i=1}^{N} (X_i - \bar{X})^2}{N-1}$$

PRECISION (IN PCT): IS A NORMALIZED VALUE OF THE STANDARD DEVIATION. IT ALLOWS YOU TO COMPARE THE SPREAD OF A SMALL NUMBER TO THE SPREAD OF A LARGE NUMBER IN A MEANINGFUL WAY.

COMPUTED BY DIVIDING THE STANDARD DEVIATION BY THE MEAN. IN THIS CASE PRECISION IS GIVEN IN PER CENT SO THE ANSWER IS MULTIPLIED BY 100.

$$\text{PREC.} = \frac{\text{S.D.}}{\text{MEAN}} \times 100$$

APPENDIX 7a

7-29-76

CVS AND ANALYTICAL UNITS CROSS CHECK
HIGHLAND PARK ENGINEERING
DEPARTMENT 5140
EMISSION DEVELOPMENT TESTING

DATE: WEEK of 9/19/77
VEHICLE TESTED: 515, 360 CID, W AUTO. TRANS.
TEST INERTIA: 4000# W AC FACTOR
TEST TYPE: HOT 505 W FLYING START
ENGINEER: A. E. PACHANA

MODAL TEST RESULTS

COMPONENT ANALYZED (in grams/mile)	METHOD OF ANALYSIS	ROLLS NUMBER							
		20	21	22	23	24	25	26	27
HYDROCARBONS	F.I.D.	DOWN	.893 .947	.830 .831	.784 .817	.947 .973	.891 .885	.902 .896	1.057 1.005
CARBON MONOXIDE	N.D.I.R.		3.82 3.82	3.72 3.58	3.75 3.66	3.72 3.70	3.79 3.76	4.11 4.10	3.66 3.60
CARBON DIOXIDE	N.D.I.R.		735 754	726 733	752 744	730 731	749 740	776 770	746 737
OXIDES OF NITROGEN	CHEM.		.931 .941	.875 .874	.976 .919	.868 .876	.944 .874	1.016 .997	.966 .936
FUEL ECONOMY	CARBON BALANCE		11.93 11.63	12.08 11.97	11.67 11.80	12.01 12.00	11.71 11.85	11.30 11.39	11.75 11.90
DISTANCE	MODAL-BAG RATIO	DOWN	3.578 3.579	3.562 3.564	3.572 3.573	3.574 3.575	3.567 3.561	3.543 3.543	3.564 3.564

COMMENTS: (1) ROLLS 20 unavailable due to dyno evaluation.

APPENDIX 7a CHRYSLER

CVS AND ANALYTICAL UNITS CROSS CHECK
HIGHLAND PARK ENGINEERING
DEPARTMENT 5140
EMISSION DEVELOPMENT TESTING

DATE: WEEK of 9/19/77
VEHICLE TESTED: 515, 360 CID W AUTO TRANS.
TEST INERTIA: 4000# W AC FACTOR

COMPONENT ANALYZER (g/mi)		MEAN	VARIANCE	S, STD. DEV.	REPEATABILITY	MEAN-2S	MEAN+2S
HYDROCARBONS	MODAL	.904	.006	.076	* 8.43%	.752	1.057
	BAG	.688	.002	.039	* 5.69%	.609	.766
CARBON MONOXIDE	MODAL	3.771	.025	.159	4.22%	3.452	4.089
	BAG	3.740	.017	.129	3.44%	3.482	3.998
CARBON DIOXIDE	MODAL	744.5	218.9	14.8	1.99%	714.9	774.1
	BAG	735.8	139.7	11.8	1.61%	712.2	759.4
OXIDES OF NITROGEN	MODAL	.928	.002	.049	5.33%	.829	1.027
	BAG	1.264	.006	.079	6.28%	1.106	1.423
FUEL ECONOMY	MODAL	11.79	.05	.23	1.96%	11.32	12.25
	BAG	11.93	.04	.19	1.58%	11.56	12.31
DISTANCE		3.566	.000	.011	0.32%	3.543	3.588

COMMENTS: (1) Repeatability for both bag and modal results are within the limits set forth in the Chrysler performance standard No.PF-6168 procedure No. LP 461 K 123, except modal and bag HC.

(2) Asterisk denotes <u>out of spec.</u>

CVS AND ANALYTICAL UNITS CROSS CHECK
HIGHLAND PARK ENGINEERING
DEPARTMENT 5140
EMISSION DEVELOPMENT TESTING

DATE: WEEK of 9/19/77
VEHICLE TESTED: 515, 360 CID, W AUTO. TRANS.
TEST INERTIA: 4000# W AC FACTOR
TEST TYPE: HOT 505 W FLYING START
ENGINEER: A. E. PACHANA

BAG TEST RESULTS

COMPONENT ANALYZED (in grams/mile)	METHOD OF ANALYSIS	ROLLS NUMBER								
		20	21	22	23	24	25	26	27	
HYDROCARBONS	F.I.D.	DOWN	.703 .737	.634 .628	.646 .652	.712 .711	.690 .718	.681 .656	.705 .754	
CARBON MONOXIDE	N.D.I.R.		3.84 3.78	3.80 3.62	3.70 3.61	3.60 3.77	3.61 3.65	3.93 4.03	3.72 3.70	
CARBON DIOXIDE	N.D.I.R.		743.5 743.1	722.5 730.1	726.4 726.9	726.2 731.8	735.5 731.2	762.0 757.4	735.5 729.2	
OXIDES OF NITROGEN	CHEM.		1.353 1.398	1.180 1.172	1.301 1.233	1.190 1.212	1.219 1.149	1.318 1.313	1.345 1.318	
FUEL ECONOMY	CARBON BALANCE		11.81 11.81	12.15 12.03	12.09 12.08	12.09 11.99	11.94 12.01	11.52 11.59	11.94 12.04	
	MODAL-BAG RATIO	DOWN								

COMMENTS: (1) ROLLS 20 UNAVAILABLE DUE TO DYNO EVALUATION.

CVS AND ANALYTICAL UNITS CROSSCHECK
CHELSEA PROVING GROUNDS
DEPARTMENT 5150
VEHICLE CERTIFICATION

DATE : September 26 and 27, 1977
VEHICLE TESTED: 855 (318 automatic w/catalyst)
TEST INERTIA : 4000#
TEST TYPE : Hot 505 w/flying start
ENGINEER : T. Kueny

BAG DATA

COMPONENT ANALYZED (in grams/mile)	METHOD OF ANALYSIS	ROLLS NUMBER							
		1	2	3	4	5	6	7	8
HYDROCARBONS	F.I.D.	.272	.300	.290	.334	.309	.285	.288	.317
CARBON MONOXIDE	N.D.I.R.	3.06	3.84	4.03	4.35	3.65	3.11	4.02	4.54
CARBON DIOXIDE	N.D.I.R.	554	559	550	561	553	558	559	563
OXIDES OF NITROGEN	CHEM.	1.76	1.84	1.79	1.95	1.79	1.89	1.90	2.01
FUEL ECONOMY	CARBON BALANCE	15.85	15.68	15.93	15.61	15.86	15.75	15.68	15.55
DISTANCE	DIGITAL COUNTER	3.58	3.56	3.60	3.60	3.58	3.59	3.60	3.59

COMMENTS: 1) All tests were driven by the same person.
2) Cells 1 and 5 were tested on September 27; all other rolls were tested September 26
3) Chrysler Laboratory Procedure LP-461K-123 was followed with the exception that single tests were obtained from each cell instead of the prescribed duplicates.

CVS AND ANALYTICAL UNITS CROSSCHECK
CHELSEA PROVING GROUNDS
DEPARTMENT 5150
VEHICLE CERTIFICATION

DATE : September 26, 1977
VEHICLE TESTED: 855 (318 automatic w/catalyst)
TEST INERTIA : 4000#
TEST TYPE : Hot 505 w/flying start
ENGINEER : T. Kueny

MODAL DATA

COMPONENT ANALYZED (in grams/mile)	METHOD OF ANALYSIS	ROLLS NUMBER							
		1	2	3	4	5	6	7	8
HYDROCARBONS	F.I.D.	.283	.410	.332	.329	.338	.296	.300	.327
CARBON MONOXIDE	N.D.I.R.	2.14	2.48	2.74	2.81	2.49	2.22	2.66	3.29
CARBON DIOXIDE	N.D.I.R.	564	567	563	566	567	561	564	569
OXIDES OF NITROGEN	CHEM.	1.65	1.75	1.74	1.90	1.76	1.86	1.86	2.02
FUEL ECONOMY	CARBON BALANCE	15.61	15.50	15.61	15.53	15.51	15.68	15.59	15.43
EXHAUST VOLUME	MODAL-BAG RATIO	324	317	316	336	319	311	317	341

COMMENTS:
1) Modal hydrocarbons from rolls 2 are excessively high with respect to both other rolls and to bag results. Analyzer shift is suspected but the overall system will be investigated.
2) Both exhaust volume and CO_2 data are high for the second consecutive week on rolls #4.

CVS AND ANALYTICAL UNITS CROSS CHECK
HIGHLAND PARK ENGINEERING
DEPARTMENT 5150
EMISSION DEVELOPMENT TESTING

DATE: September 26, 1977
VEHICLE TESTED: 855 (318 automatic w/catalyst)
TEST INERTIA: 4000#

COMPONENT ANALYZER (g/mi.)		MEAN	VARIANCE	S, STD. DEV.	REPEATABILITY%	MEAN-2S	MEAN+2S
HYDROCARBONS	MODAL	.327	.0015	.039	11.9	.249	.405
	BAG	.299	.0004	.020	6.7	.260	.339
CARBON MONOXIDE	MODAL	2.60	.132	.36	14.0	1.88	3.33
	BAG	3.83	.285	.53	14.0	2.76	4.89
CARBON DIOXIDE	MODAL	565	6.70	2.6	.5	560	570
	BAG	557	19.3	4.4	.8	548	566
OXIDES OF NITROGEN	MODAL	1.82	.0133	.115	6.4	1.59	2.05
	BAG	1.87	.0076	.087	4.7	1.69	2.04
FUEL ECONOMY	MODAL	15.56	.01	.08	.5	15.40	15.72
	BAG	15.74	.02	.13	.8	15.47	16.00
EXHAUST VOLUME	MODAL CALC.	323	111	10.5	3.3	302	344

COMMENTS:
1) According to Chrysler Performance Standard PF-6168, maximum allowable percent variation for a vehicle omitting at these levels is 10% HC, 15% CO, 10% NO_x and 3% CO_2. Only modal hydrocarbons exceed this limit and is denoted with an asterisk.
2) Modal-bag agreement for CO_2, NO_x and fuel economy is excellent; agreement for HC and CO is poor but is influenced by the low emissions levels measured.

CORRELATION VEHICLES

A. BOTH SMALL AND LARGE ARE DESIRABLE.

B. SET SCHEDULE FOR SITES AND DEVELOP A BASELINE.

C. MONITOR COAST DOWN Δt'S AFTER TEST.

D. PLOT DATA AND DO STATISTICS FOR ONE MONTH PERIOD (40 TESTS)
(EXAMPLE 2 TESTS/DAY × 20 DAYS ÷ 8 SITES = 5/SITE)

APPENDIX 7B

DON PAULSELL EPA

DB	WB	H	Kh	% Δ
74	64	75.2	1.001	0
73	63	72.0	.986	-1.5
72	62	68.9	.972	-2.9
71	61	65.9	.959	-4.2

BARO = 29.0"

EFFECT OF ERROR IN TEMPERATURE MEASUREMENT
FOR SAME "Δ T"

APPENDIX 8 DICK LAWRENCE EPA

SHED SYSTEM

	QC CHECK	TECHNIQUE	FREQUENCY	ACCURACY
1.	SHED Volume	Propane Injection	At Introduction	$\pm$ 2%
2.	SHED Background	4 Hour Check	Yearly	.4 gm max
3.	SHED Leakage	Propane Injection	Monthly	4% in 4 hours

APPENDIX 9a

BRUCE GARDNER, FORD

SHED SYSTEM

General

- M-VEL Designed
  - Enclosure
  - Console
  - Cooling System
- Enclosure
  - "Guillotine" Style Door
  - Pneumatic Door Seal
  - Two - 420 cfm Centrifugal Blowers
  - Medium and High Volume SHEDS
- Console
  - "State of the Art" Components
  - Computer Interface Capability
  - Manual Diurnal Heating
  - High Level Signal Conditioning
  - Self - Contained Diagnostic Devices
  - "Prom" Type - System Controller
- Cooling System
  - Internally Mounted Cooling System
  - Closed - Loop Servo Controlled
  - Water - to - Water Heat Exchanger
  - Manual Override Capabilities

APPENDIX 9B

T.L.S. - 10/5/77
G.M.P.G.

IN-PROCESS QC TECHNIQUES

A. CALIBRATION GAS MONITORING

B. DVU HORSEPOWER CHECK OF ARLC

C. TEST DATA RATIOS AND LIMITS

- VMIX 2/1 AND 1/3
- CO2 BAG X/TOTAL GMS
- BKGD LEVELS
- NOX-KH
- RPM RATIO FOR PDP-CVS

APPENDIX 10

DON PAULSELL-EPA