EPA-AA-EOD/FSB-86/3

Technical Report

CVS Exhaust Connnecting Hose Upgrade

June 1985 - September 1985

Carl Paulina

NOTICE

Facility Support Branch
Engineering Operations Division
Mobile Source Air Pollution Control
Environmental Protection Agency
2565 Plymouth Road
Ann Arbor, Michigan 48105

Summary

Between June 4 and September 12, 1985, the Environmental Protection Agency (EPA) Motor Vehicle Emission Laboratory (MVEL) upgraded the exhaust connecting hose assemblies which connect vehicle tail pipes to the Constant Volume Samplers (CVSs) used for vehicle emissions and fuel economy testing. This report details the upgrade and examines fuel economy aspects of the upgrade.

Red silicone gaskets were added to the Marman flange connections on the flexible stainless steel hose which connects the test vehicle to the CVS. In addition, the single, six foot long section of 4-1/2 inch diameter hose was divided into four sections, two sections three feet long and two end caps. The sections are connected by silicone boots (See Attachment 1, Drawing T0492A). All flange and tubing diameters and interior and exterior surfaces remain unchanged. Gasketed flanges provide better seals, reducing the potential for erroneous data due to exhaust leaks. The large flexible hose was divided into four sections to make it easier to connect the exhaust connecting hose to the wide variety of vehicle and tail pipe configurations that are tested by EPA. These upgrades were made to help ensure measurement of the "true mass of gaseous emissions" as required in CFR 86.109-82.

Four independent data sources were reviewed to estimate the new connecting hose influence on gasoline vehicle fuel economy results. They are as follows:

1. Weekly diagnostic propane injections
2. General Motors correlation program
3. Volvo REPCA weekly hot LA-4 tests
4. Manufacturer-EPA certification paired data

The indicated shifts in EPA measured fuel economy values from each of the four data sources are:

Data Source (Driving Schedule)	Shift in Dyno Group Average	Dynos Included No. of Tests (Old/New)
Propane Injection	None (None expected)	
General Motors Correlation (Hot LA-4)	0.6 - 0.8% lower F.E.	Dynos 1,2,5,6 (12/12)
Volvo REPCA (Hot LA-4)	1.9% lower F.E.	Dynos 1,2,3,4,5,6 (114/138)
Paired Data (FTP)	0.7% lower F.E.	Dynos 1,2,5,6 (266/236)
(HWFET)	0.9% lower F.E.	Dynos 1,2,5,6 (286/284)

Background

Vehicle tail pipes are connected to Constant Volume Samplers (CVS) during a Federal Test Procedure (FTP) emission test and Highway Fuel Economy Test (HWFET). A flexible connecting hose is used to carry the entire vehicle exhaust flow into the CVS where it is diluted, proportionally sampled, and the sample accumulated throughout the driving schedule. The sample is then analyzed for hydrocarbon (HC), carbon monoxide (CO), carbon dioxide (CO_2), and oxides of nitrogen (NOx) composition. Leakage resulting in the loss of a portion of the "raw exhaust" stream (before dilution) will lower final emission values and raise fuel economy values.

Pulsing and resonance due to the vehicle engine and CVS blower may become great enough to actually drive sample out of the CVS connecting hose if leak points exist. Our routine diagnostic test, the Federal Register (FR) CVS verification by propane injection, will not detect a "leaky" flexible connecting hose assembly. Without the pulsing and resonance present during a vehicle test, there is no driving force to push the propane out through leak points of the connecting hose assembly.

Since propane injections will not show this type of leakage, a technique was needed to quantify the effect this leakage might have on emission test results. The most "repeatable" vehicle (emission grams/mile or miles per gallon) could exhibit too much variation to allow it to be used to gauge an effect of this low a magnitude.

To overcome this, a comparison technique was used which minimizes variations from the vehicle and dynamometer. We call this comparision FE% (Equation One).

$$FE\% = \frac{(\text{Carbon balance MPG} - \text{Volumetrically Metered MPG}) * 100}{\text{Volumetrically Metered MPG}} \qquad \text{(Equation One)}$$

The control measurement of this comparison is volumetrically metered fuel economy from an independent flow transducer. The percent difference between vehicle carbon balance fuel economy and volumetrically metered fuel economy (FE% Equation One) fits the requirements for a method to gauge the possible shift in carbon balance (40 CFR Sec. 600113-78) vehicle fuel economy. Variations resulting from changes in the vehicle and dynamometer will be reflected in both meter and carbon balance fuel economy, while changes due to the elimination of exhaust leaks will be reflected only in carbon balance fuel economy. Sample leakage is not the only possible influence on FE% (Equation One). The major ones are:

1. Fuel meter variation
2. Facility fuel changeover
3. CVS air flow calculation variation
4. Carbon dioxide analyzer variations
5. Sample leakage (New Exhaust Implementation)

We have reviewed data on all the above influences for the time period considered in this report. Of the above influences, the only influence corresponding to shifts in FE%, both by date and direction, is a possible sample leakage decrease due to the introduction of new exhaust connecting hoses.

Physical Modifications

Leak testing showed that the primary points of leakage were the metal-to-metal Marman flange interfaces. The Marman flanges were modified to allow the installation of a silicone gasket between the stainless steel flange faces. The next most likely points of leakage were through the walls of the 4-1/2 inch metal-flex or convoluted hose which connects the vehicle tail pipe to the CVS. The new 4-1/2 inch metal-flex hose contains stainless steel wire as packing in the interlocking sections of the hose to minimize leakage through the walls. The 4-1/2 inch connecting hose was divided into two three-foot sections which could be connected with 4-1/2 inch ID silicone boots (See Attachment 1). The boots are used with band clamps to insure a positive seal on the 4-1/2 inch connecting hose ends. Each CVS test site was equipped with the set of connectors shown in Attachment 2.

Actual Implementation

The new exhaust connecting hose was implemented on each of the six gasoline test sites on the following dates:

Dynamometers (CVS)		Implementation Dates
D006	(25c)	6/5/85
D005	(29c)	7/17/85
D001	(21c)	7/20/85
D002	(22c)	8/6/85
D003	(23c)	8/30/85
D004	(24c)	9/12/85

Before implementation on each CVS site, a complete set of connecting hoses was manufactured, assembled, and tested for leaks. The leak check procedure and apparatus are outlined in Attachment 3. A leak rate for each assembly of connecting hoses was recorded before they were placed on-site. Once the new hoses were on-site, propane injections were performed. Normal Volvo REPCA two-bag hot LA-4s were run using each site's old exhaust connecting hose and then a new connecting hose. To establish that no static pressure difference was introduced with the new exhaust connecting hose assemblies, strip chart recordings were run of vehicle tail pipe depression during the REPCA LA-4s. The tail pipe depressions were within the $\pm$ 1 inch of water which the Federal Register allows manufacturers to request [Sec. 86.109-82(c)(1)].

The connecting hose assembly leak checks will be performed periodically to establish a diagnostic leak check frequency for maintenance.

An Equipment/Procedure Change Notice (EPCN) was written (EPCN #64, Attachment 1) to diagram and document the changes made. Finally, a complete set of assembly and component drawings were generated showing all individual components used in the system, part numbers, and manufacturers (Attachment 3).

Effect on Test Results

Four independent data sources were reviewed to estimate the new connecting hose influence on gasoline vehicle fuel economy results. They are as follows:

1. Weekly diagnostic propane injections
2. General Motors correlation program
3. Volvo REPCA weekly hot LA-4 tests
4. Manufacturer-EPA certification paired data

1. Propane Injections:

Propane injections are run on a weekly basis to verify CVS operation. No shift was apparent on any of the six CVS sites equipped with a new connecting hose assembly. No effect was expected. A Critical Flow Venturi (CFV) CVS operating by itself, does not seem to create the pulsations which appear responsible for forcing sample out of the connecting hoses.

2. GM Correlation:

A General Motors correlation program was run between August 16 and August 21, 1985. The testing took place on Dynamometers 1, 2, 5, and 6 (CVSs 21C, 22C, 29C, and 25C, respectively). One connecting hose assembly was used as the "old" connecting hose on all sites. Each CVS site had three hot LA-4 tests with the "old" connecting hose and three tests with the "new" connecting hose. The individual new/old tests were alternated on each site (A-B sequence). Two sites began their test series with "new" connecting hoses and two began their test series with the "old" connecting hoses. The program results are summarized in Technical Report EPA-AA-EOD/TPB-85-2, "Assessment of the Hot Start Fuel Economy Effects of a New CVS Exhaust Connector Pipe Design". It states that the overall difference in carbon balance fuel economy mean values, using an overall total of twelve tests in each new and old configuration on 4 sites, was estimated as 0.6 percent lower fuel economy with the new exhaust connecting hose. Using FE% (equation one) as an indicator, GM estimated 0.8 percent lower fuel economy with the new exhaust connecting hose.

3. Volvo REPCA:

Volvo REPCA is a repeatable vehicle which has a two bag hot LA-4 test run weekly on each CVS site. These weekly tests were used as a data source. The date range of this data set is from March through December 31, 1985.

Absolute emission values, from even the most repeatable vehicle, may exhibit trends with time. These trends can prevent using emission values as a tool to gauge an effect as subtle as the suspected sample leakage. Specifically, the linear trends of REPCA's HC, CO, NOx, carbon balance fuel economy, and volumetrically metered fuel economy over this period are of the same order of magnitude as the influence of the suspected leaks. For example, despite an expected increase in measured emissions due to a decrease in leakage, Volvo REPCA NOx emission values actually decreased from "old" to "new" connecting hose tests. This is probably due to a change in vehicle parameters (Air/fuel ratio, O_2 sensor decay, spark plug condition, etc.)

The percent difference between carbon balance and volumetrically metered fuel economy (FE% Equation One) was the most sensitive indicator examined. Graphs of Volvo REPCA FE%,for Bags 1 and 2 versus CVS sites are contained, along with graphs of individual sites FE% for bags 1 and 2 versus calendar date, in Attachment 4.

Fuel economy percent (FE%) Bag 1 was arithmetically averaged with FE% Bag 2 for each Volvo REPCA test and labeled Fuel Economy Percent Weighted (FE% WGT). The mean values of FE% WGT were then calculated for both "new" and "old" connecting hose tests. The overall mean FE% WGT was approximately 1.8% lower with the "new" connecting hose than with the "old", based on 114 "old" connecting hose tests and 138 "new" connecting hose tests.

Since the CVS sites were converted one at a time from June 4 through September 12, 1985, the number of REPCA tests on each CVS site (old/new) was different. We wanted to insure that our comparison was not influenced by one CVS site. We calculated an average of the six CVS site means for both "new" and "old" tests. This analysis showed FE% WT was approximately 1.9% lower with the "new" connecting hoses (Attachment 5). Both comparisons used all the Volvo REPCA tests run from March through December 31, 1985.

4. Paired Data

Finally, manufacturer-EPA certification FTP and HWFET paired data for mile per gallon percent difference (Equation Two) versus dynamometer site, along with individual sites MPG % differences versus calender date, is contained in Attachment 6.

MPG % = [(manufacturer MPG - EPA MPG)/(EPA MPG)] * 100 (Equation Two)

The graphs in Attachment 6 display the data points used to generate the statistics in Attachment 7. The time span for these graphs is March 1 through December 31, 1985. One assumption upon which this analysis is based is that no change has taken place at manufacturers' facilities that could account for the shifts.

The vast majority of certification tests for this period occurred on Dynamometer sites 1, 2, 5 and 6. An average of the four individual site means was taken to equally weight each CVS when generating the before and after overall facility MPG% Difference. The change in the four site average value

for FTP MPG % Difference (Equation Two) when examined this way is 0.7% lower fuel economy with the "new" connecting hose using 266 pairs "old" and 236 pairs "new." The change in the four-site average value for HWFET MPG % Difference (Equation Two) is 0.9% lower fuel economy with "new" connectors using 286 pairs with "old" connectors and 284 pairs with "new" connectors (see Attachment 7).

Conclusions and Recommendations

1. The "new" exhaust connectors result in lower carbon balance fuel economy when compared to tests with "old" connectors.

2. The primary points of leakage are the metal-to-metal Marman flange interfaces. Silicone gaskets will eliminate this leakage.

3. FE% (Equation One) is the most sensitive indicator for this change.

4. The graphs of FE% and MPG% Difference versus Site (Attachments 4&6) indicate the new exhaust connecting hose tends to make fuel economy values more repeatable CVS to CVS than the old connecting hose.

5. Certification test vehicles have an inherent variability which lessens the statistical confidence of discernable effect.

6. Exhaust connectors should be leak tested periodically to ensure that they do not contribute to sample leakage. Propane injections will not reveal this phenomenon.

7. FE% on Volvo REPCA tests should be monitored weekly to further guarantee collection hose integrity.

Attachments

1. Equipment/Procedure Change Notice #64
2. New System Assembly Drawings and bill of materials
3. Leak Check Procedure
4. Fuel Economy Percent (FE%) Change Graphs - Volvo REPCA
5. Volvo REPCA "New"/"Old" Statistics
6. Paired Data Change Graphs
7. Paired Data "New"/"Old" Statistics

0436e

EQUIPMENT/PROCEDURE CHANGE NOTICE

EPCN NO.	DATE ENTERED	PAGE
64	7 / 16 / 85	1 OF 1

1. ORIGINATOR	2. PHONE EXT.	3. REVIEW DUE DATE:
Carl Paulina	421	ENTER "FYI" AS APPLICABLE

4. DIVISION CLEARANCE

5. TYPE OF CHANGE: ☐ FED. REGISTER ☒ EQUIPMENT ☐ A/C ☐ MSAPC PROCEDURE ☐ FORM ☐ OTHER

6. REFERENCE DOCUMENTS (List Attachments, Forms, Procedures, FR's, etc.)
TP-707B

7. DESCRIPTION OF CHANGE (Attach details, specifications, drawings, and implementation plan).

This change consists of the addition of gaskets to the Marmon flange connections in the flexible pipe which connects the vehicle tailpipe to the constant volume sampler. See Drawing 1. In addition, the single, six foot long section of 4 1/2 inch diameter pipe is being divided into two sections, each three feet long. The sections will be connected by a silicone boot. See Drawings 2 and 3. All flange and tubing diameters, interiors and exteriors remain the same before and after this change.

8. PURPOSE OF CHANGE (Why is this change being proposed?)

Gasketed flanges provide better seals reducing the potential for erroneous data due to undetected exhaust leaks. The large flexible pipe is being divided into two sections to make it easier to connect the exhaust collection tubing to the wide variety of vehicle and tailpipe configurations that are tested by EPA.

9. PROPOSED EFFECTIVITY (Date, MY, etc.)	10. DURATION OR EXTENT OF USE
JULY 1985	☒ PERMANENT ☐ TEMPORARY

11. AREAS OF MSAPC AFFECTED BY THIS CHANGE

☐ LDT ☐ E & D ☐ INST. SERV. ☐ CHEM LAB. ☐ QC/QA ☐ ECTD
☐ HDT ☐ C & M ☐ RTS HDWR. ☐ TEST VALID. ☐ DATA BR. ☐ CSD
☐ OTHER

12. REVIEWS AND APPROVALS

REVIEWED BY	INIT.	DATE	CONCURRENCE	COMMENTS
A. John T. White, Chief Testing Programs Branch	JTW	7/16/85	☑ YES ☐ NO	
B. James D. Carpenter, Chief Facility Support Branch	JDC	7/16/85	☑ YES ☐ NO	
C. Don Paulsell, Chief ~~Engineering Staff~~	CDP	7/17/85	☒ YES ☐ NO	

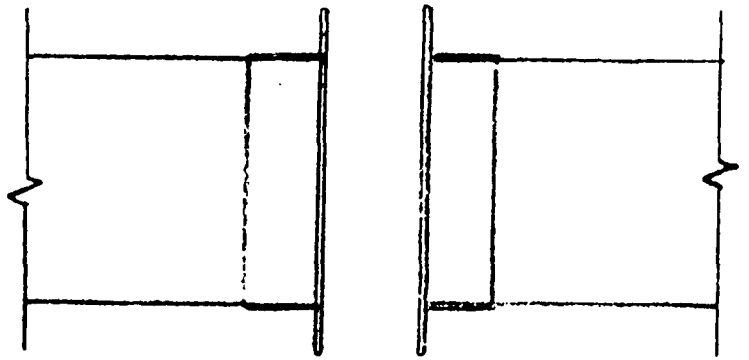
13. DIVISION RESPONSE	DATE	RECOMMENDED ACTION
Signature Donald D. Stanley	7/18/85	APPROVE ☐ DISAPPROVE ☐ CONDITIONAL APPROVAL ☐ (Comments) REQUEST TO REVIEW REDRAFTS ☐
THE REVIEWS AND RESPONSES NOTED HAVE BEEN RECEIVED AND DOCUMENTED.	DATE 7/18/85	14. EPCN CONTROLLER REDRAFT REQUIRED ☐ RELEASED FOR IMPLEMENTATION ☐

THE PROVISIONS OF THIS EPCN ARE HEREBY AUTHORIZED FOR IMPLEMENTATION.	15. AUTHORIZED BY: John White for RDL	DATE 7/18/85

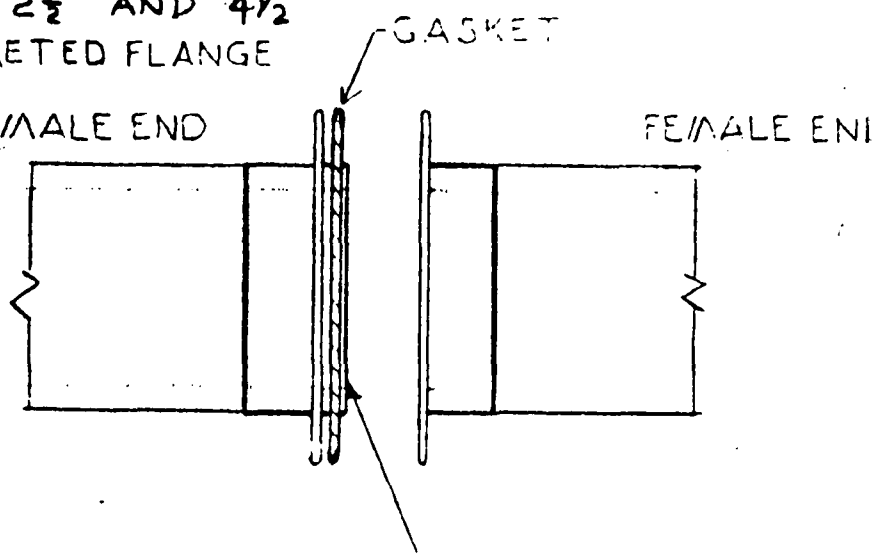
MSAPC FORM 7.5 REVISED: 7/1/75

DISTRIBUTION: ORIGINAL (White) - EPCN LOG; COPY 1 (Yellow) - DIVISION LOG; COPY 2 (Blue) - EPCN INTERIM LOG; COPY 3 (Pink) - RETAINED BY ORIGINATOR

OLD 2½" AND 4½" FLANGE



NEW 2½" AND 4½"
GASKETED FLANGE



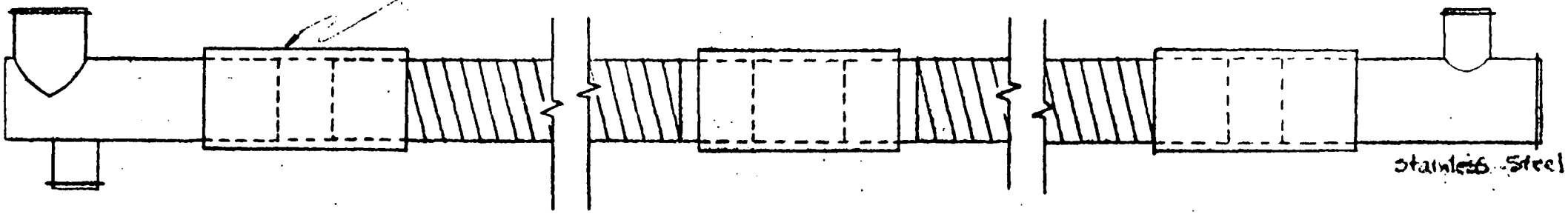
PILOT TUBE -
EXTENDS BEYOND
FLANGE FACE .1875"

GASKET THICKNESS = 1/16"

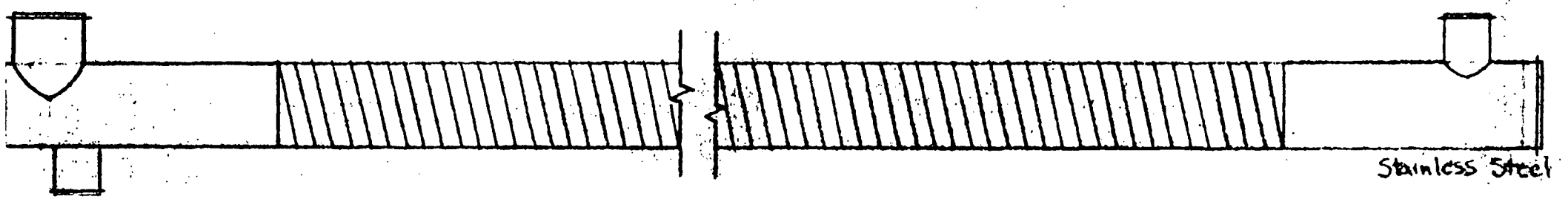
GASKET MATERIAL = SILICON (RED)

EPA	DATE 5-15-85	LAST REVISION	T0491A
	DRAWN A. McCARTHY	SCALE	
	TITLE EXHAUST COLLECTION HOSE DRWG#1		

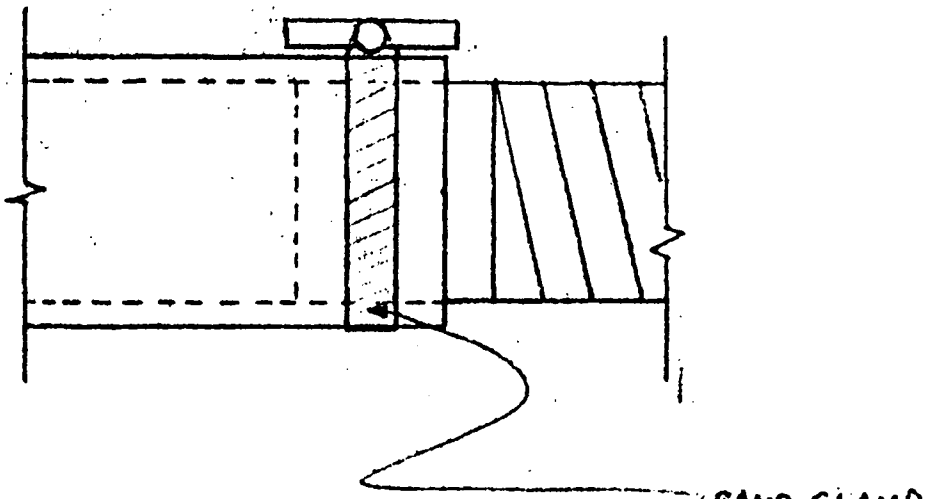
NEW SETUP



OLD SETUP



BOOT DETAIL

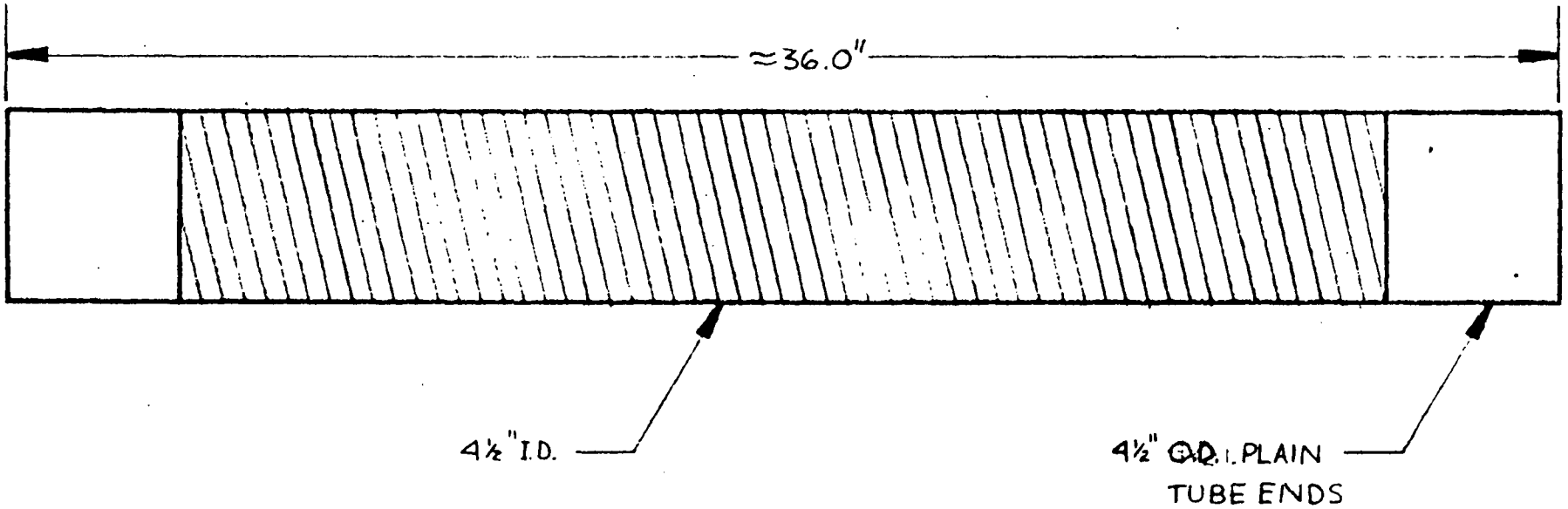


BOOT MATERIAL: SILICONE

BOOT THICKNESS: ½"

EPA	DATE 5-15-85	LAST REVISION	T0492A
	DRAWN A. McCARTHY	SCALE	
	TITLE EXHAUST COLLECTION HOSE DRWG. #2		

EXHAUST COLLECTION HOSE SECTION



EPA	DATE 5-22-85	LAST REVISION	T0493A
	DRAWN A. McCARTHY	SCALE	
	TITLE EXHAUST COLLECTION HOSE DRWG. 3		

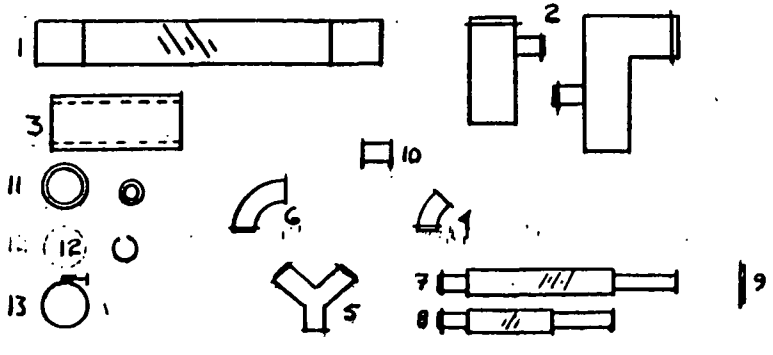
Large Convoluted Exhaust Flex-pipe Specification

	Old Hose	New Hose
Manufacturer	Federal Hose Manuf. Co.	Federal Hose Manuf. Co.
Diameter	4-1/2" I.D.	4-1/2" I.D.
Material	Stainless Steel	Stainless Steel
Packing	Unknown	Stainless Steel Wire
Part #	P360S	P360S
Description	Unlined interlocking medium duty unlined flexible stainless steel hose	Unlined interlocking medium duty stainless steel hose with plain tube ends and stainless steel wire packing

#0155e

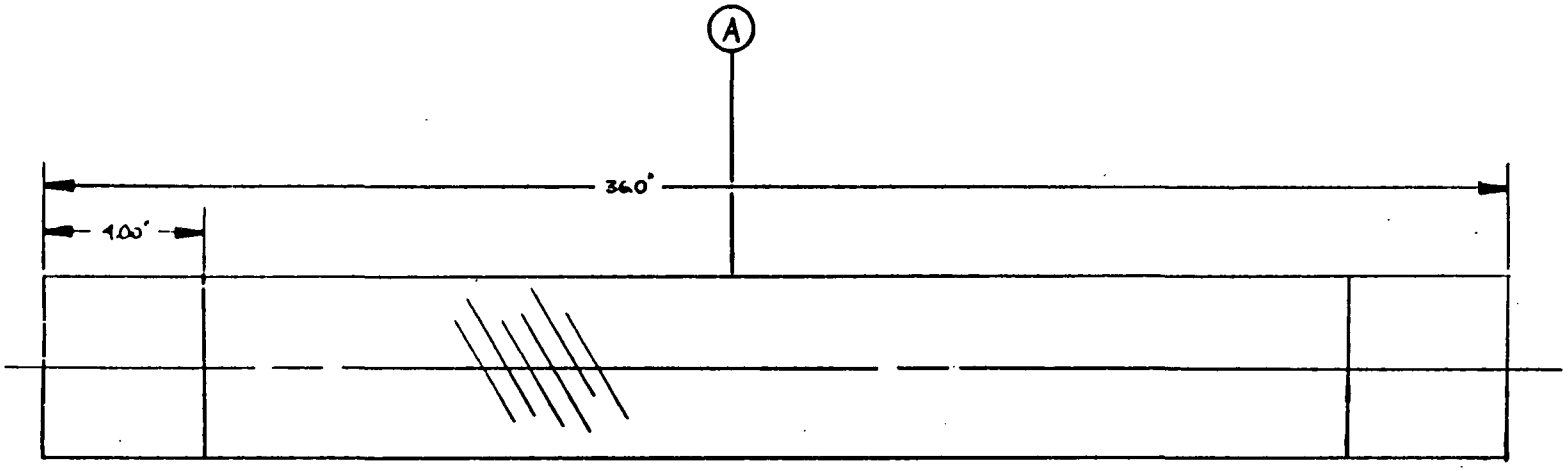
PARTS LIST PER DYNO

	QNTY	DRAWING #
1) 4½" x 36" CONVOLUTED TUBE	2	T04888-1
2) 4½" END ADAPTER	2	T04888-2A, 2B
3) 4½" I.D. SILICONE BOOT	3	T04888-3
4) 2½" TUBE - 45° ELBOW	3	T04888-4
5) 2½" TUBE - "WYE"	1	T04888-5
6) 2½" TUBE - 90° ELBOW	2	T04888-6
7) 2½" x 36" FLEX-PIPE	1	T04888-7
8) 2½" x 24" FLEX-PIPE	1	T04888-8
9) 4½" END CAP	1	T04888-9
10) 2½" TUBE - FEMALE TO FEMALE ADAPTER	1	T04888-10
11) 4½" & 2½" SILICONE GASKETS	2 & 10 RESP.	T04888-11
12) 2½" STAINLESS STEEL CIR-CLIP	10	T04888-12
13) BAND CLAMP	8	T04888-13



NOTE: L NOT INCLUDED ON NEW SYSTEM PARTS INVENTORY ARE THE MARMON FLANGE CLAMPS REUSED FROM PREVIOUS SYSTEM.

EPA	DATE 12-17-86 / LAST REVISION 5-6-86	T04888-0
	DRAWN A. McCARTHY / SCALE NONE	
	TITLE EXHAUST COLLECTION SYSTEM - OVERALL	



REORDER INFO.
PART
A 1½" O.D. METAL HOSE ST. STEEL, PACKED ⅜" ST. STEEL WIRE 36" OVERALL LENGTH WITH 1⅝" O.D "PLAIN TUBE" WELDED ENDS MNFR - FEDERAL HOSE MNFRG.

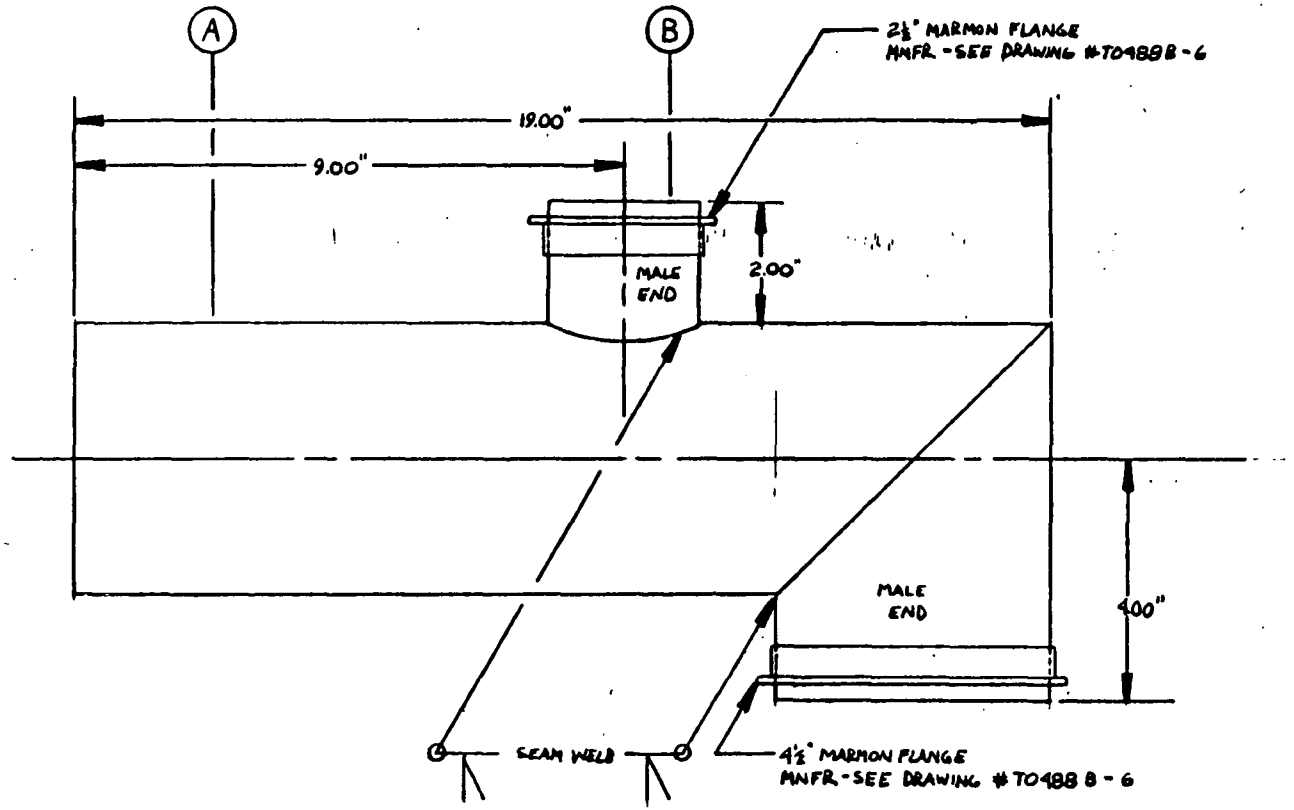
EPA MOTOR VEHICLE EMISSION LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MI. 48105

TITLE: EXHAUST COLLECTION SYSTEM - 36" CONVOLUTED TUBE

REFERENCE:

DATE 12-17-85
DRAWN A. McCARTHY
SCALE .533" = 1.00"

T0488B - 1



REORDER INFO.	
PART	
A	4" PIPE (4.5" O.D.) - 12 GA. 304L ST. STEEL MNFR. - FELKER BROS. CORP.
B	2.5" O.D. (TUBE) 16-GA. - 304L ST. STEEL MNFR. - FELKER BROS. CORP.

EPA

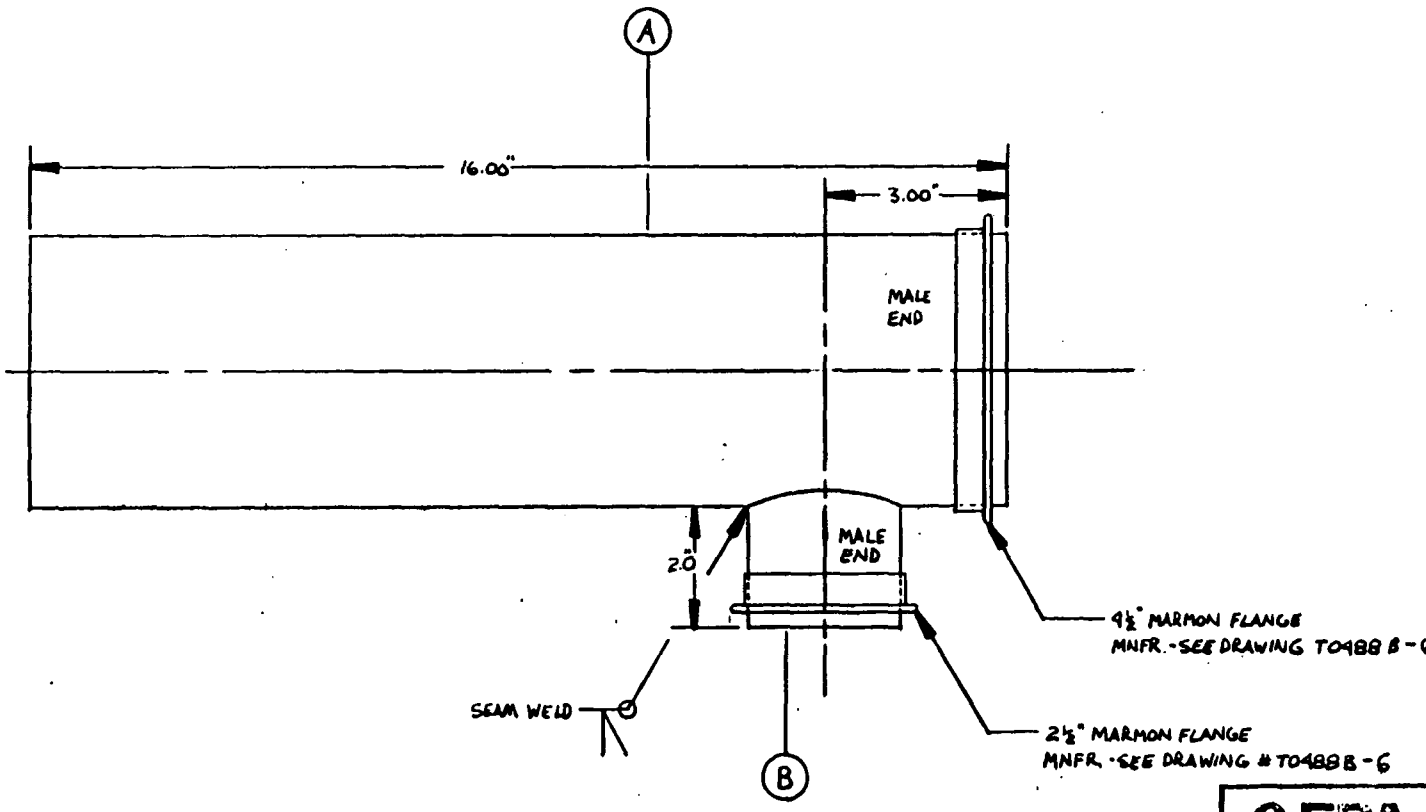
MOTOR VEHICLE EMISSION LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MI. 48105

TITLE
EXHAUST COLLECTION SYSTEM - END ADAPTER

REFERENCE

DATE 12-17-85
DRAWN A. McCARTHY
SCALE .500" = 1.00"

T0488 - 2A



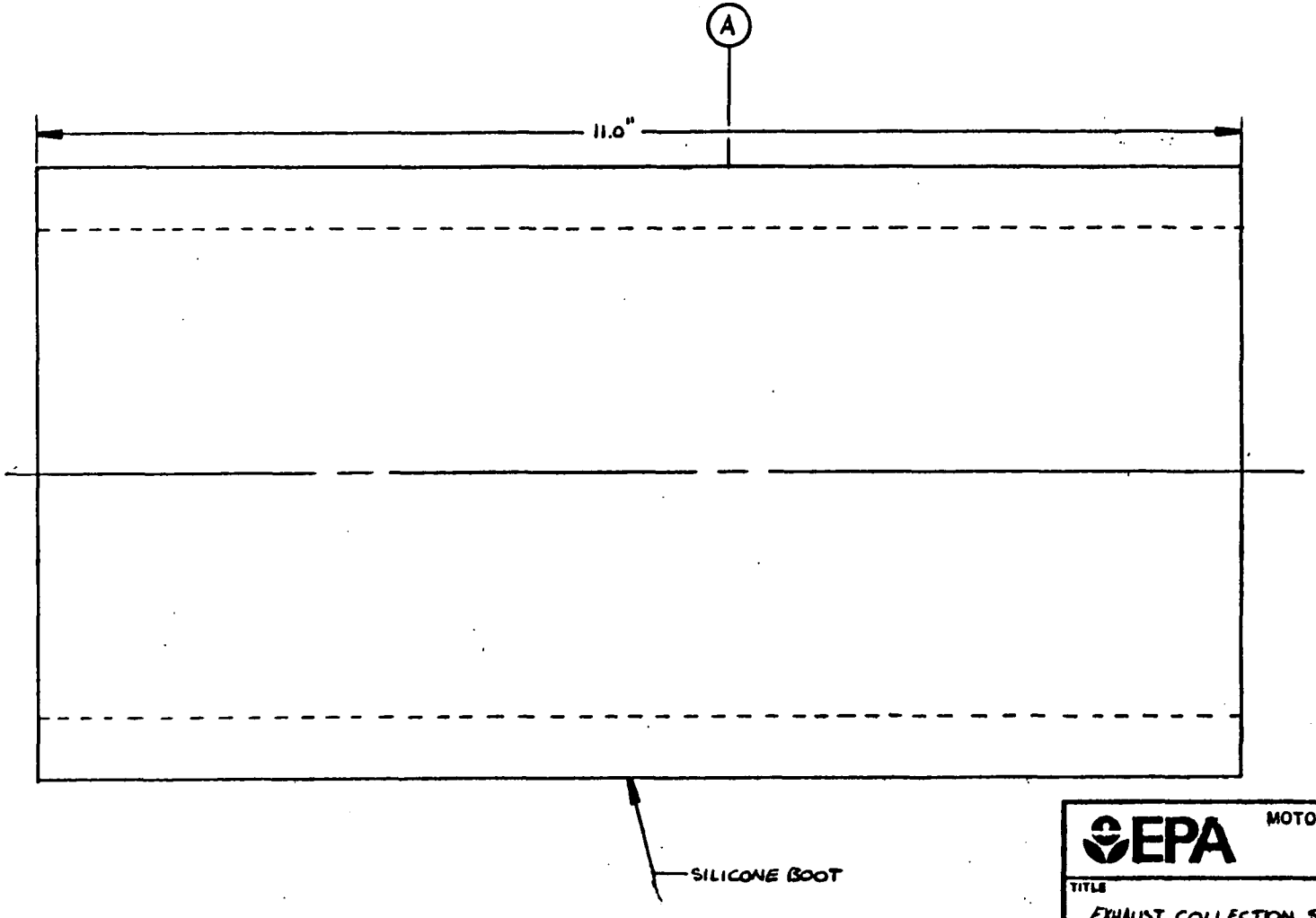
REORDER INFO.
PART
A 4" PIPE (4.5" O.D.) x 12 GAUGE 304L ST. STEEL MNFR.- FELKER BROS. CORP.
B 2.50" O.D. (TUBE) 16 GA. - 304L ST. STEEL MNFR. - FELKER BROS. CORP.

EPA MOTOR VEHICLE EMISSION LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MI. 48105

TITLE: EXHAUST COLLECTION SYSTEM - END ADAPTER

REFERENCE:

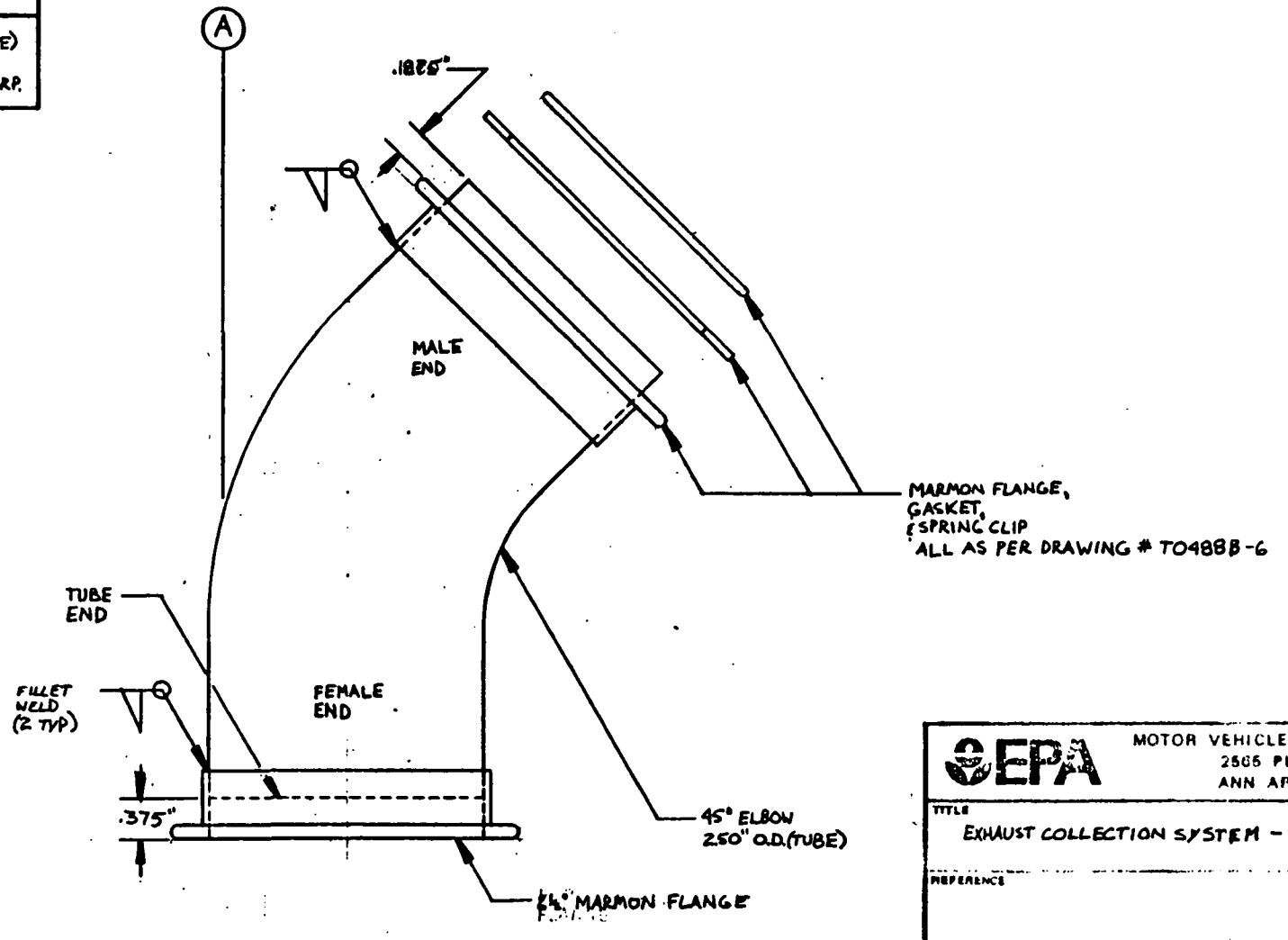
DATE 12-11-85	T0488 B - 28
DRAWN A. McCARTHY	
SCALE .500" = 1.00"	



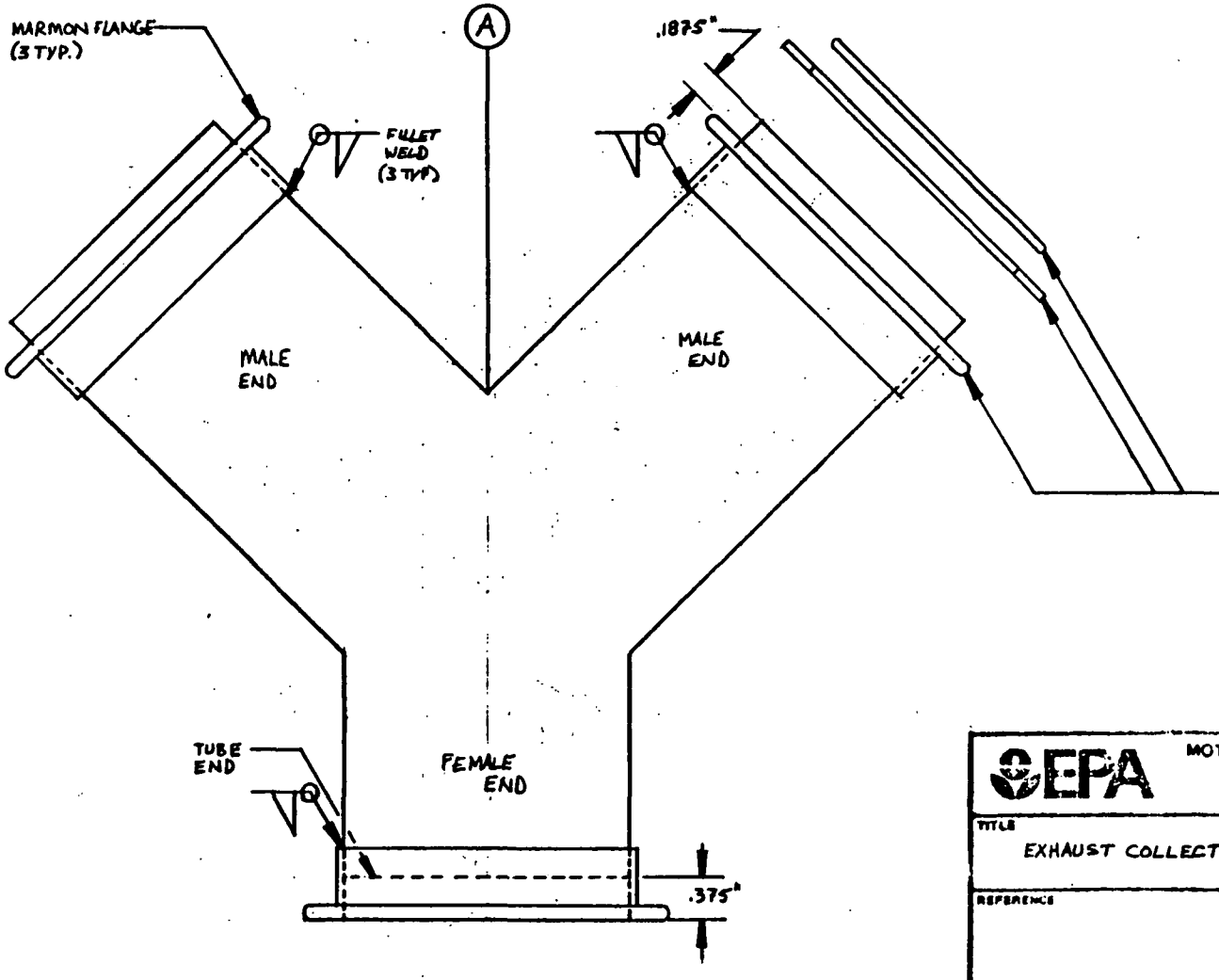
REORDER INFO.
A SILICONE BOOT 4½" I.D. ⅜" WALL TH. (INCLUDING NOMEX WRAP) NOMEX WRAP OUTSIDE MNFR.-MOLDED RUBBER

EPA	MOTOR VEHICLE EMISSION LABORATORY 2565 PLYMOUTH ROAD ANN ARBOR, MI. 48105
TITLE	EXHAUST COLLECTION SYSTEM - SILICONE BOOTS
REFERENCE	
DATE 12-17-85	TO 4806 # 3
DRAWN A. McCARTHY	
SCALE FULL	

REORDER INFO	
PART .	
A	45° ELBOW - 2.50" O.D. (TUBE) 16 GA. - 304L ST. STEEL MNFR. - FELKER BROS. CORP.



EPA	MOTOR VEHICLE EMISSION LABORATORY 2565 PLYMOUTH ROAD ANN ARBOR, MI. 48105
TITLE	EXHAUST COLLECTION SYSTEM - 45° ELBOW (2½" TUBE)
REFERENCE	
DATE 6-14-85 BY A. McCARTHY SCALE FULL	T0488B-9



REORDER INFO	
PART	
A	WYE - 2.50" OD. (TUBE) 16 GA. - 304L ST. STEEL MNFR. - FELKER BROS. CORP.

EPA — MOTOR VEHICLE EMISSION LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MI. 48105

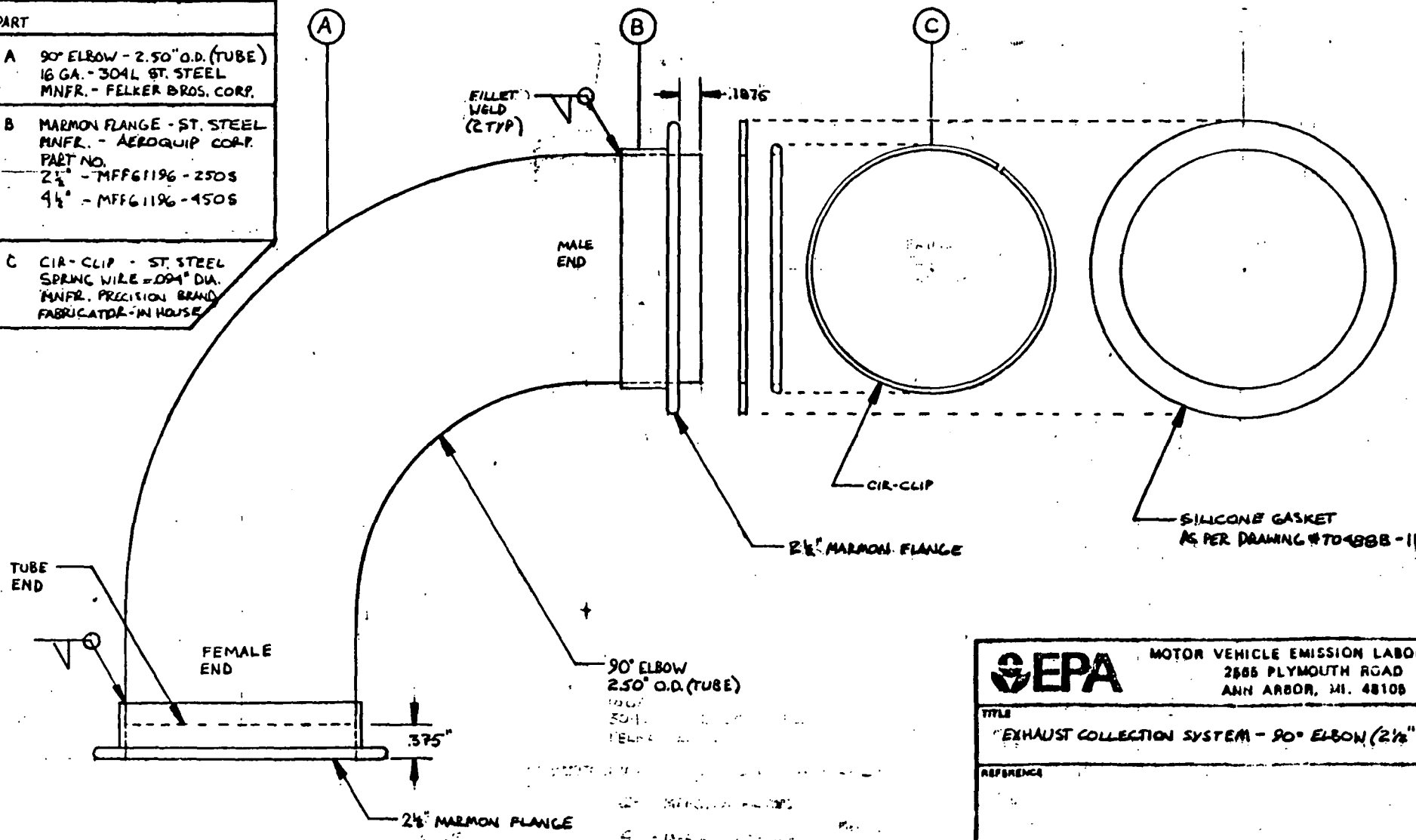
TITLE: EXHAUST COLLECTION SYSTEM - WYE (2½" TUBE)

REFERENCE:

DATE 6-25-85
DRAWN AMcCARTHY
SCALE FULL

T04BBB-5

REORDER INFO.	
PART	
A	90° ELBOW - 2.50" O.D. (TUBE) 16 GA. - 304L ST. STEEL MNFR. - FELKER BROS. CORP.
B	MARMON FLANGE - ST. STEEL MNFR. - AEROQUIP CORP. PART NO. 2½" - MFF61196-2505 4½" - MFF61196-4505
C	CIR-CLIP - ST. STEEL SPRING WIRE = .094" DIA. MNFR. PRECISION BRAND FABRICATOR-IN HOUSE



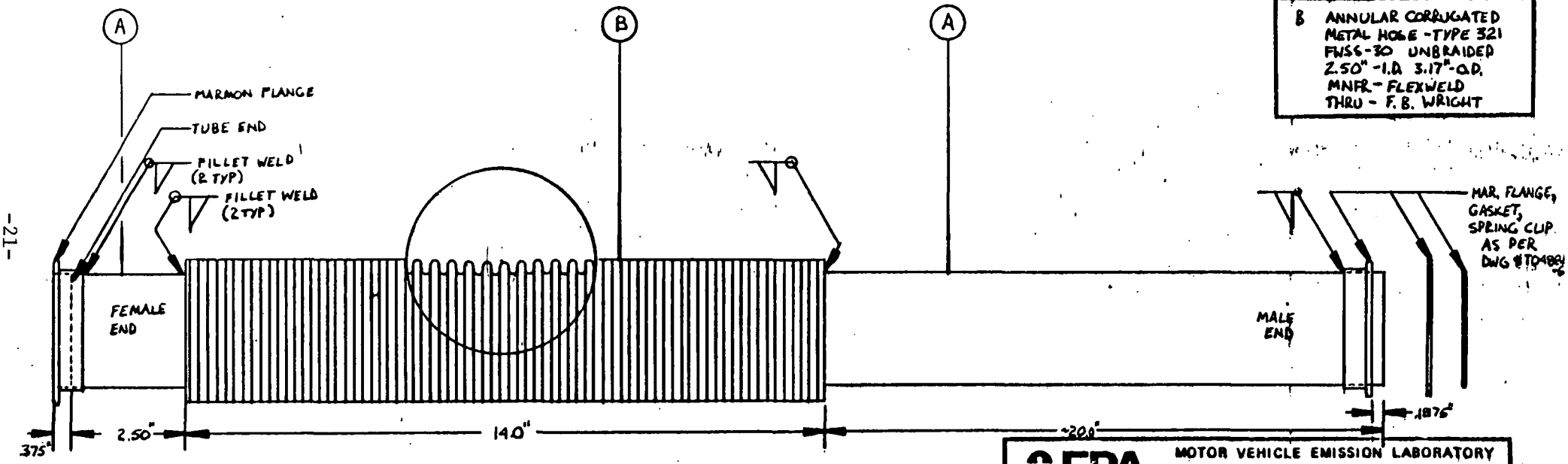
EPA

MOTOR VEHICLE EMISSION LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MI. 48105

TITLE: EXHAUST COLLECTION SYSTEM - 90° ELBOW (2½" TUBE)

REFERENCE:

DATE 6-13-85	T0488B-6
DRAWN A. McCARTHY	
SCALE FULL	



RE-ORDER INFORMATION	
PART	
A	2.50" O.D. (TUBE) 16-GA. - 304L ST. STEEL MNFR. - FELKER BROS. CORP.
B	ANNULAR CORRUGATED METAL HOSE - TYPE 321 FWSS-30 UNBRAIDED 2.50" - I.D. 3.17" - O.D. MNFR. - FLEXWELD THRU - F. B. WRIGHT

EPA

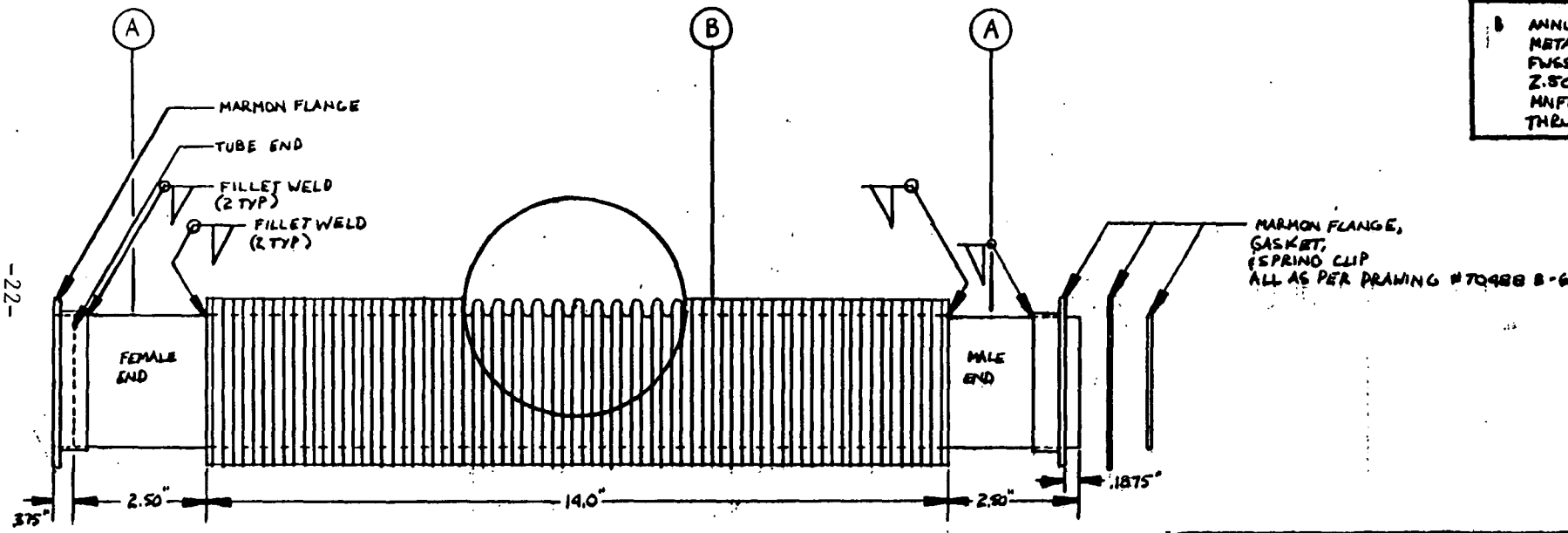
MOTOR VEHICLE EMISSION LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MI. 48105

TITLE: EXHAUST COLLECTION SYSTEM - 36" FLEX TUBE (2.5" TUBE)

REFERENCE:

DATE	10-22-85
DRAWN	A. McCARTHY
SCALE	.500" = 1.000"

TO-488 B - 7



REORDER INFO	
PART	
A	2.50" O.D. (TUBE) 16-GA. - 304L ST. STEEL MNFR. - FELKER BROS. CORP.
B	ANNULAR CORRUGATED METAL HOSE - TYPE 321 FWSS-30 UNBRAIDED 2.50"-I.D. 3.17"-O.D. MNFR.- FLEXWELD THRU. - F.B. WRIGHT

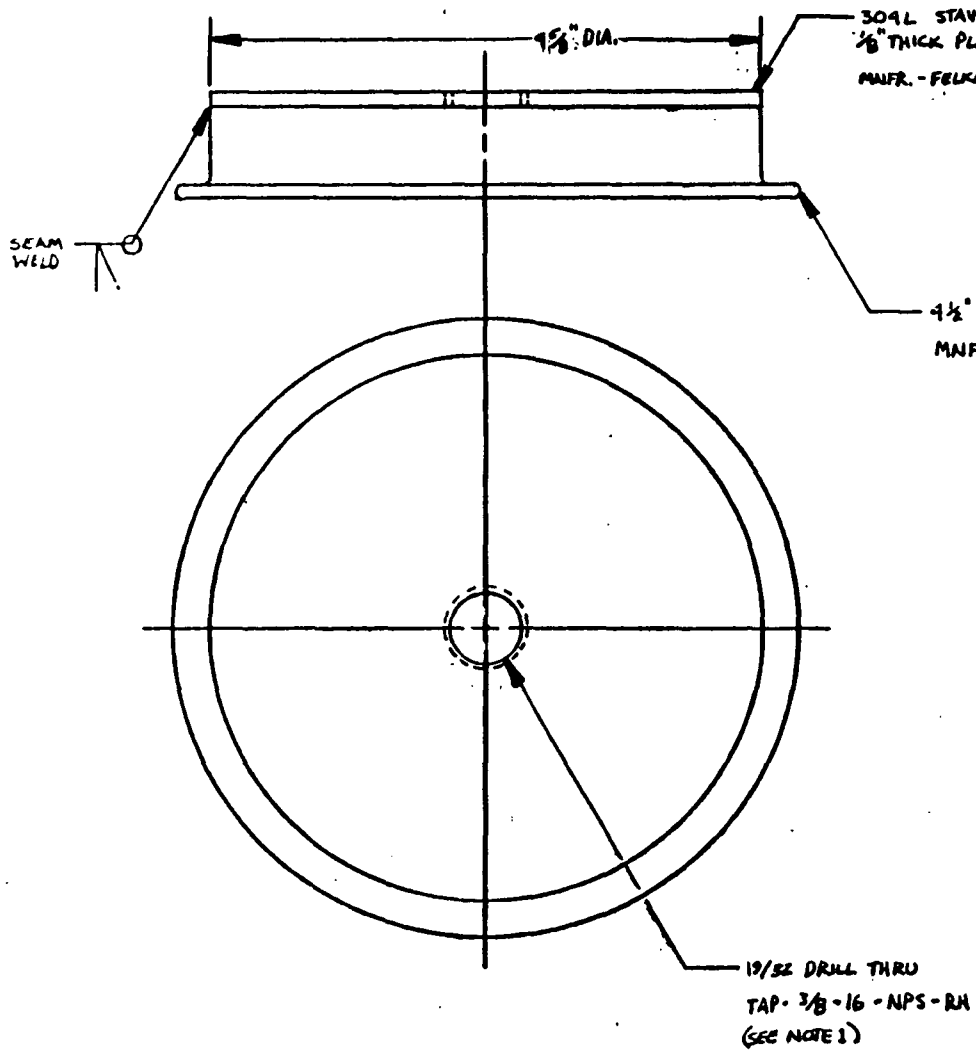
EPA MOTOR VEHICLE EMISSION LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MI. 48105

TITLE: EXHAUST COLLECTION SYSTEM - 19" FLEX TUBE (2½" TUBE)

REFERENCE:

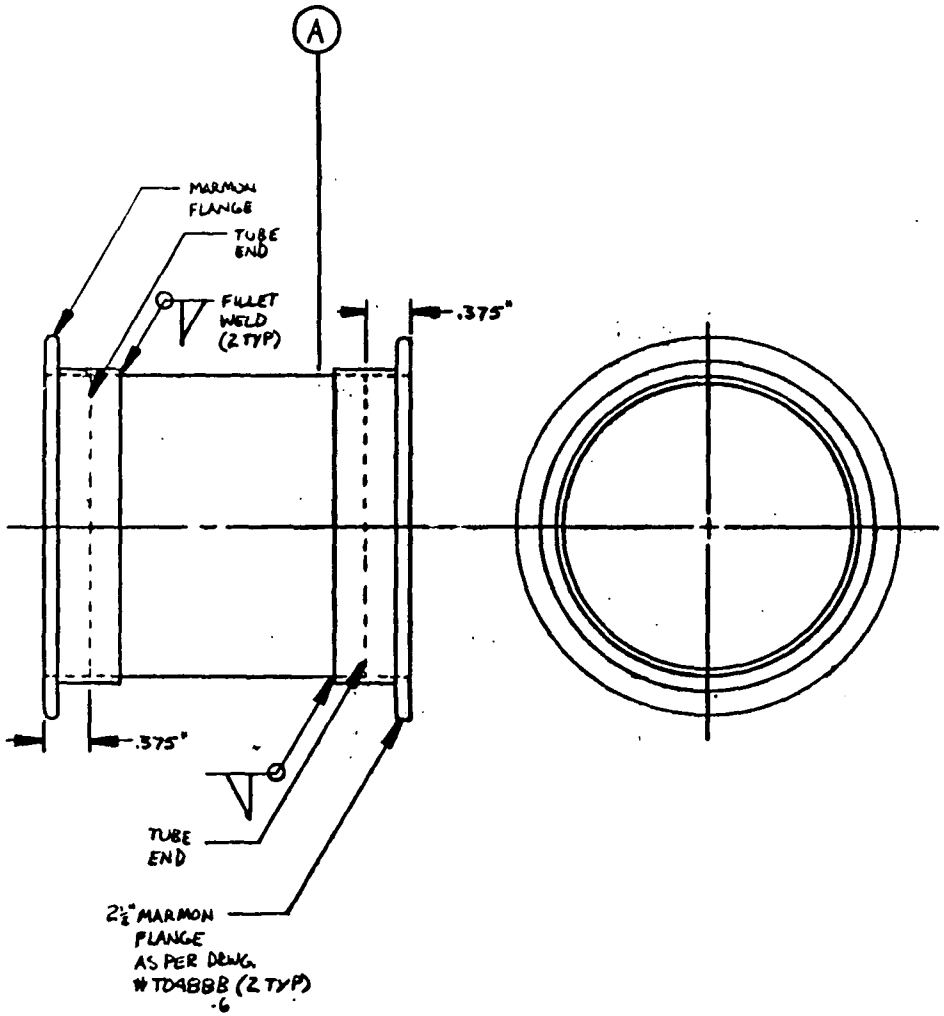
DATE 7-1-85
DRAWN A. McCARTHY
SCALE ½" = 1"

T0488 B-8



NOTE: 1) HOLE TO BE DRILLED & TAPPED FOR INSTALLATION OF THERMOCOUPLE FITTING USED AS ACCESS POINT FOR RAW GAS SAMPLE PROBE.

EPA	MOTOR VEHICLE EMISSION LABORATORY 2565 PLYMOUTH ROAD ANN ARBOR, MI. 48105
TITLE	EXHAUST COLLECTION SYSTEM - 4½" END CAP
REFERENCE	
DATE 11-20-85	T0488 B - 9
DRAWN A. McCARTHY	
SCALE FULL	

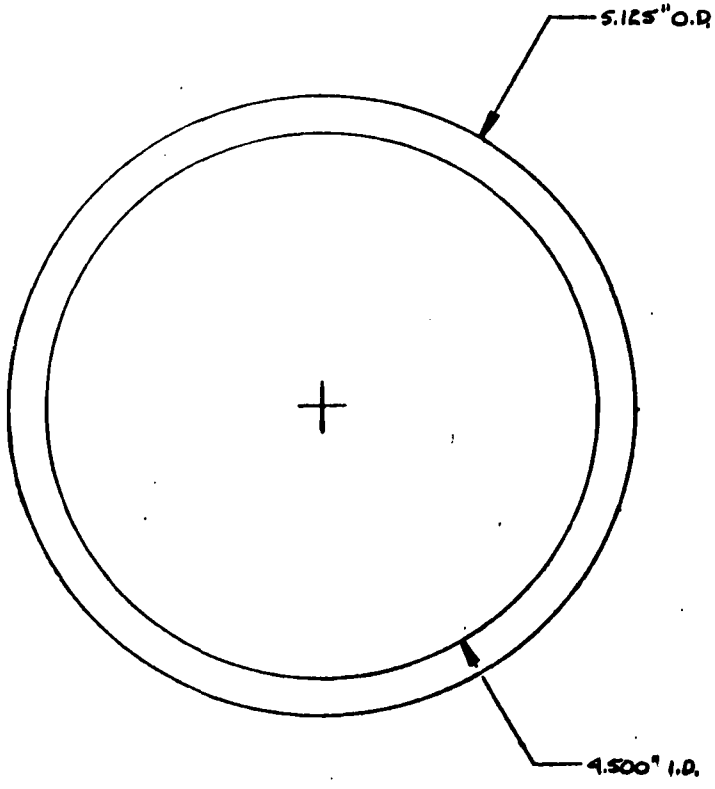


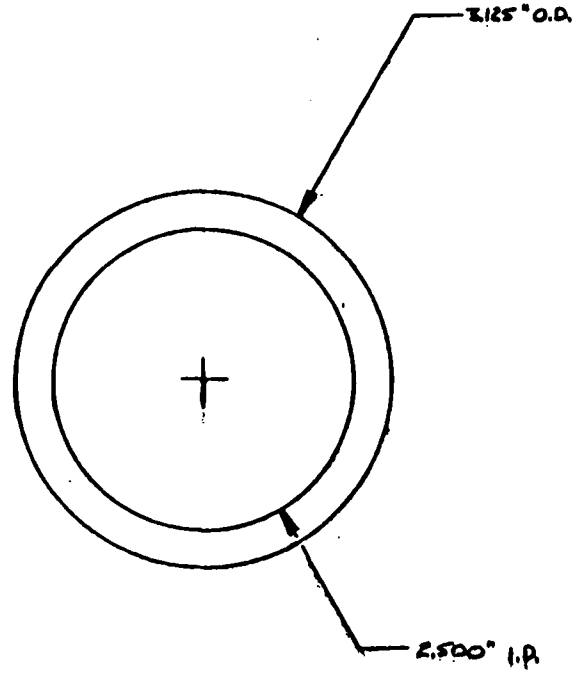
RE-ORDER INFORMATION
PART
A 2.50" O.D. (TUBE) 16 GA. - 304L ST. STEEL MNFR. - FELKER BROS. CORP.

NOTE) 1. PART SHOULD BE CONSTRUCTED 3.00" - 6.00" LONG.

EPA	MOTOR VEHICLE EMISSION LABORATORY 2565 PLYMOUTH ROAD ANN ARBOR, MI. 48105
TITLE: EXHAUST COLLECTION SYSTEM - NON-COMITTED ADAPTER	
REFERENCE:	
DATE 10-24-85 DRAWN A. McCARTHY SCALE FULL	TO 488 B - 10

REORDER INFO
SILICONE SHEET
4751 HIGH TEMP (RED)
MANF. - ROGER ZATKOFF





NOTE: BOTH GASKETS CONSTRUCTED FROM 1/16" SILICONE SHEET

EPA

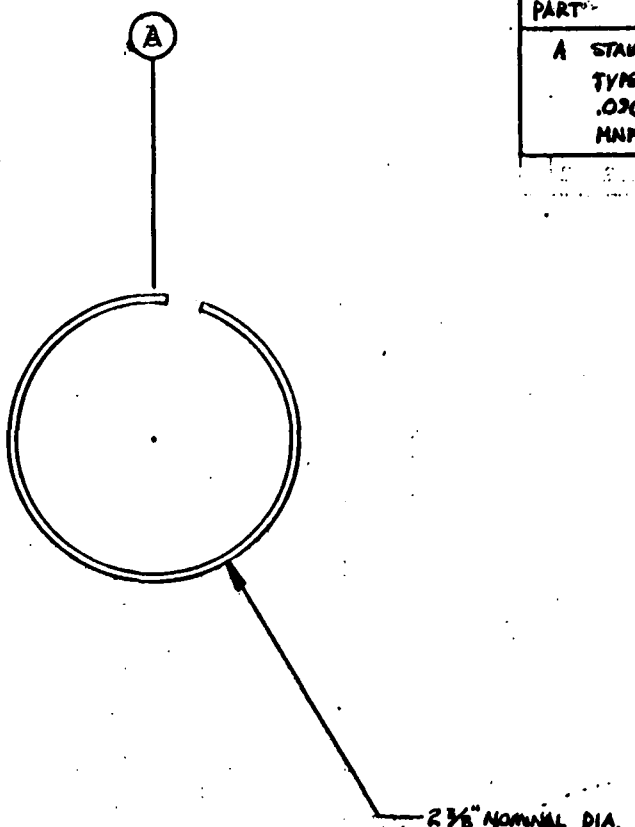
MOTOR VEHICLE EMISSION LABORATORY
2565 PLYMOUTH ROAD
ANN ARBOR, MI. 48105

TITLE: EXHAUST COLLECTION SYSTEM - GASKET DETAIL #1

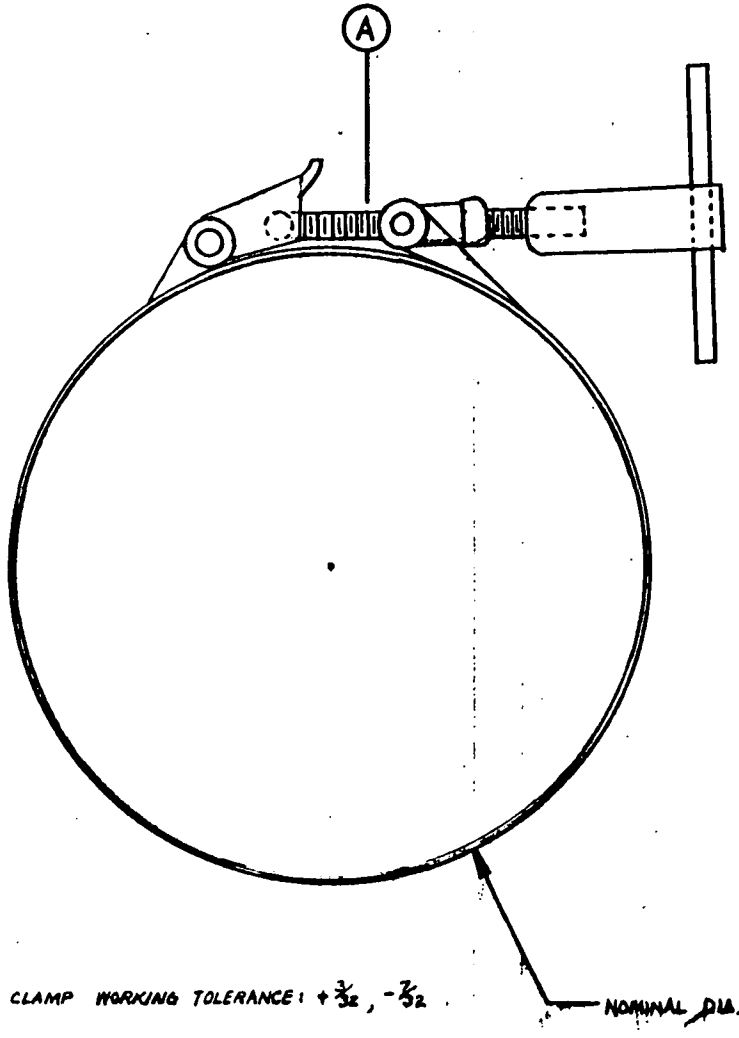
REFERENCE:

DATE 12-10-85	T0488#11
DRAWN A. MCCARTHY	
SCALE FULL	

RE-ORDER INFO.
PART
A STAINLESS STEEL CIR-CLIP TYPE 302 SPRING TEMPER WIRE .030 DIA. MNFR.- PRECISION BRAND PRODUCTS



EPA	DATE 05-06-86	LAST REVISION	T04888-12
	DRAWN A. MCCARTHY	SCALE FULL	
	TITLE CIR-CLIP DETAIL		



RE-ORDER INFO	
PART	
A	QUICK RELEASE BAND CLAMP WITH T-HANDLE TR-405-75-975-T MNFR. VOSS INDUSTRIES

NOTE: 1. CLAMP WORKING TOLERANCE: $+\frac{3}{32}$, $-\frac{7}{32}$.

EPA	DATE 05-06-86	LAST REVISION	
	DRAWN A. MCCARTHY	SCALE NONE	TO 9888-13
	TITLE BAND CLAMP DETAIL		

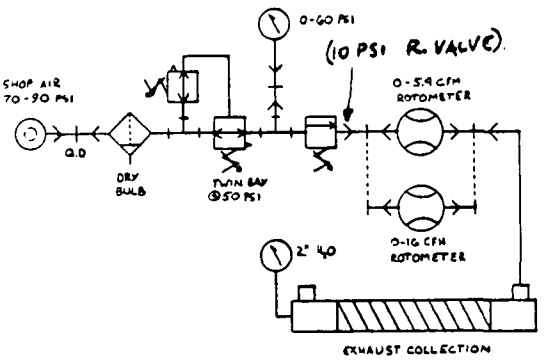
Attachment 3

Implementation Plan - System Leak Check

1. Assemble a complete dyno exhaust collection hose (all adapters).

2. Leak check with all adapters connected and all outlet ports capped.

Test schematic:



The leak check procedure will consist of pressurizing the assembly with a shop air source which has a rotometer in line. Pressurize the exhaust collection hose to 2"H_2O positive pressure (negative pressure leakage will only be additional dilution air). The approximate flow (measured by a rotometer) needed to maintain 2"H_2O will then be defined as system leakage.

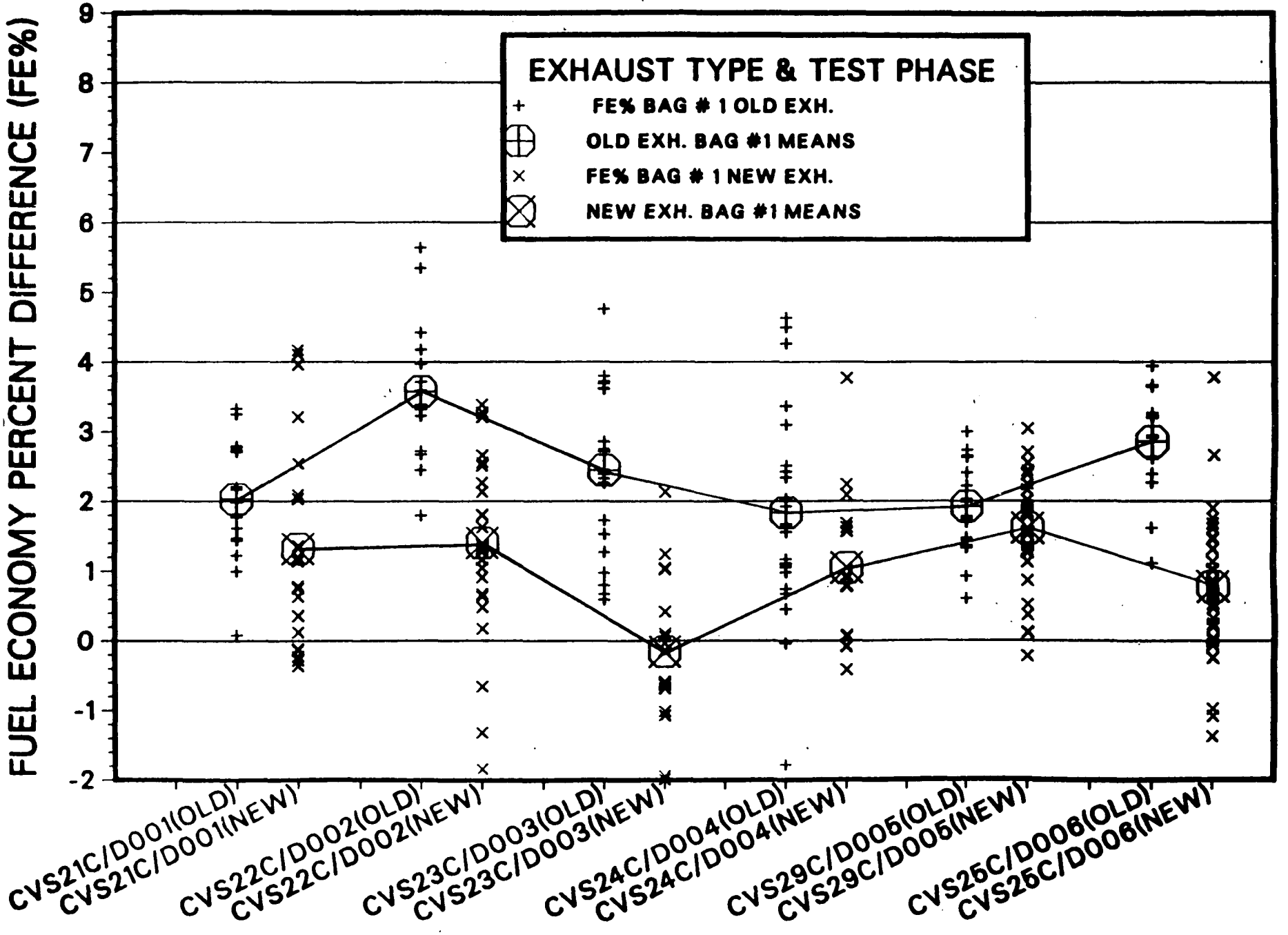
a. New exhaust hose will be leak checked before installation and flow recorded.

b. Old exhaust collector hose will be leak checked, immediately following removal, and flow recorded.

VOLVO REPCA FE% VS TEST SITE(EXHAUST TYPE)

FE%=[(CARB. BAL. FE - METERED FE)/(METERED FE)]*100

HOT START BAG #1 VALUES

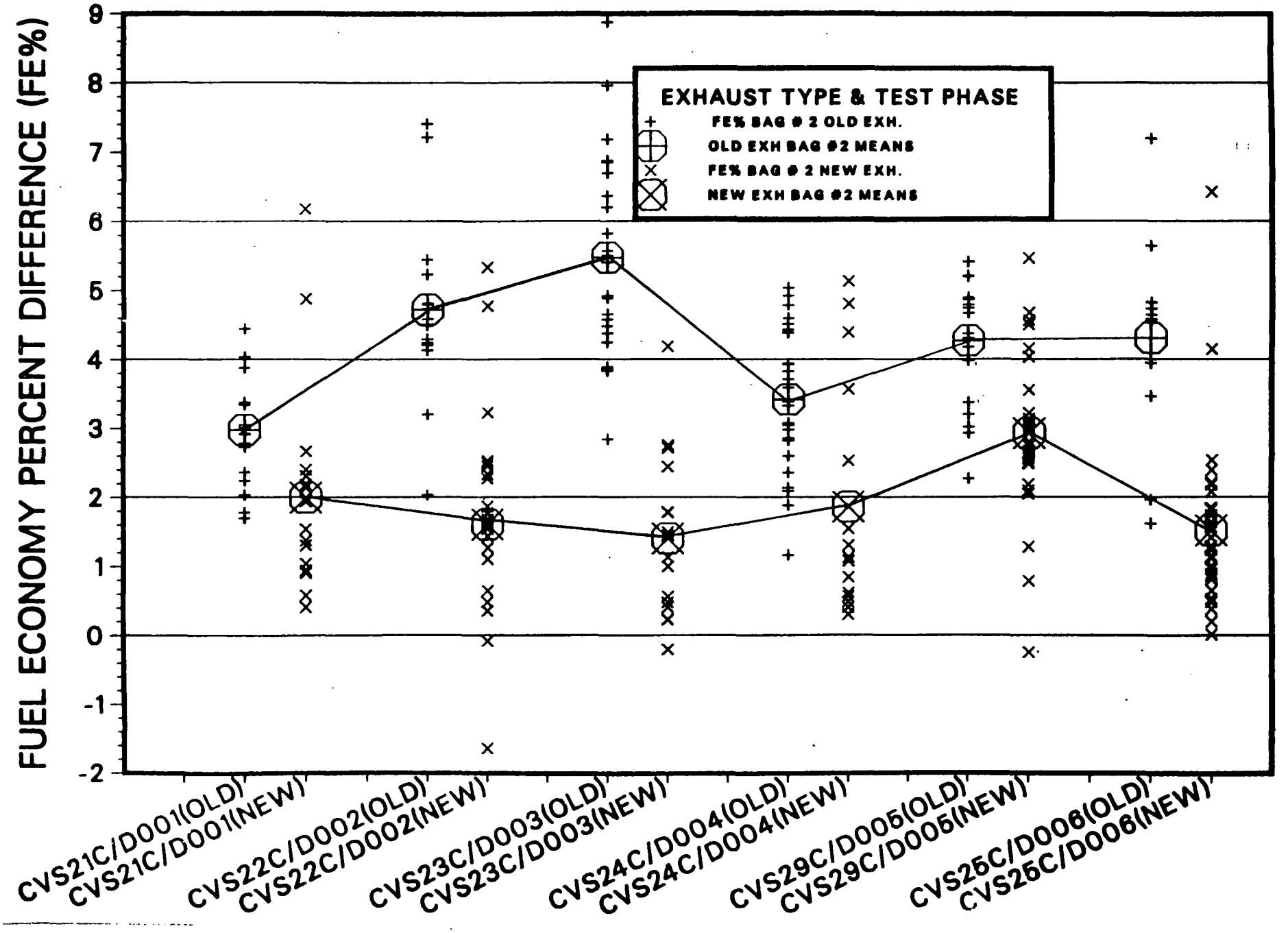


Attachment 4

VOLVO REPCA FE% VS TEST SITE(EXHAUST TYPE)

FE%=[(CARB. BAL. FE - METERED FE)/(METERED FE)]*100

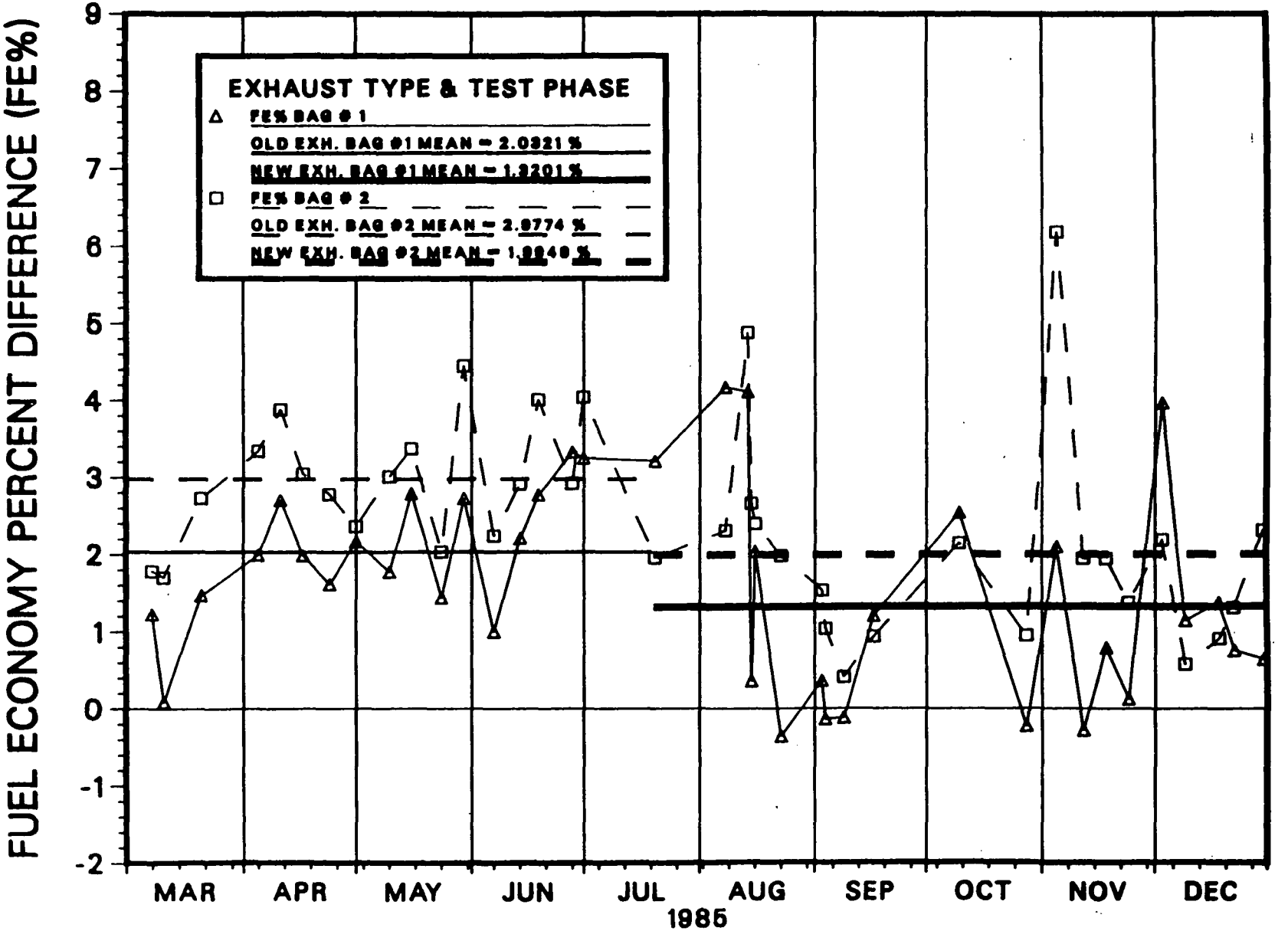
HOT START BAG #2 VALUES



VOLVO REPCA FE% CHRONOLOGICALLY

FE%=[(CARB. BAL. FE - METERED FE)/(METERED FE)]*100

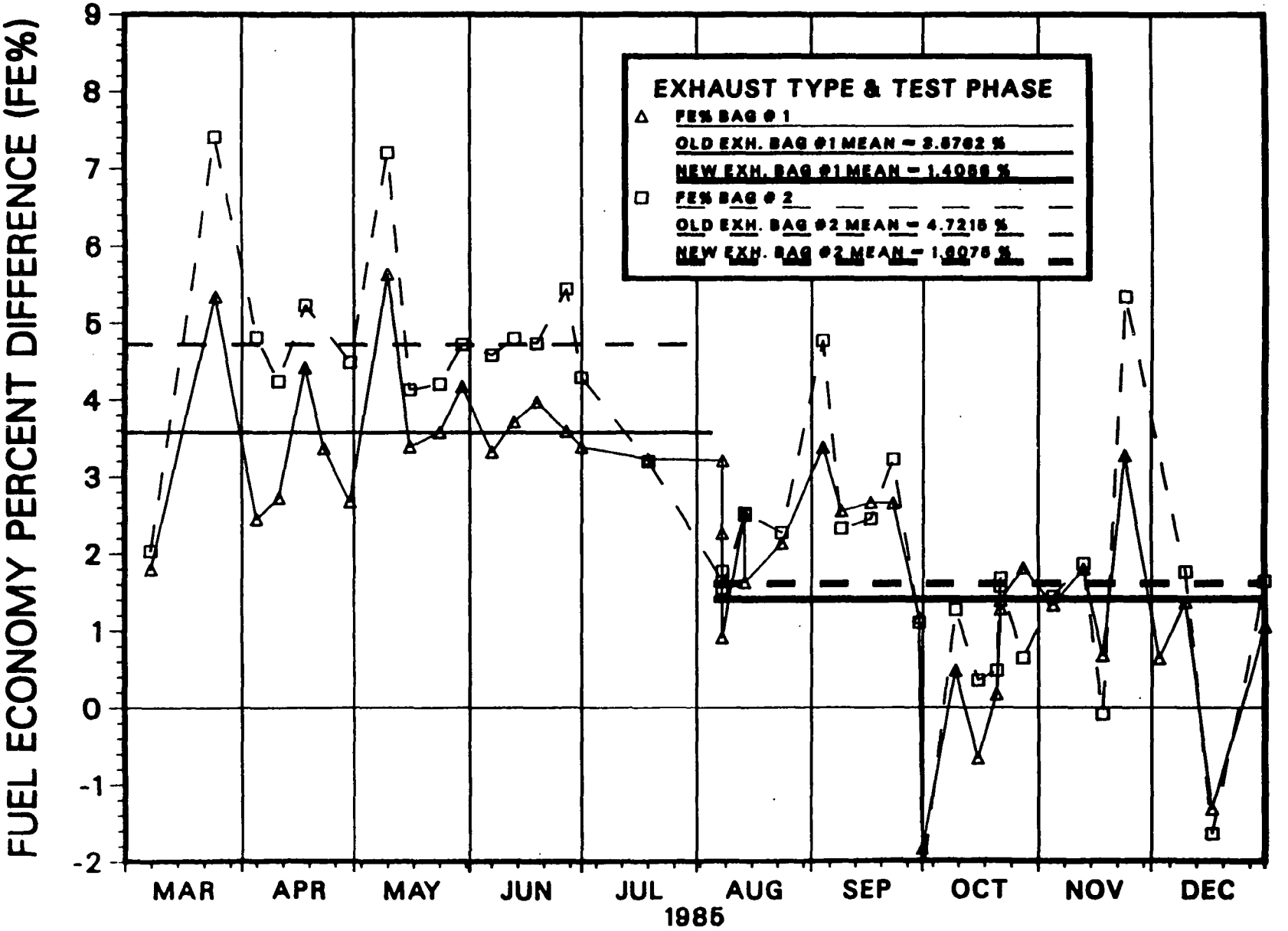
CVS 21C, DYNO D001



VOLVO REPCA FE% CHRONOLOGICALLY

FE%=[(CARB. BAL. FE - METERED FE)/(METERED FE)]*100

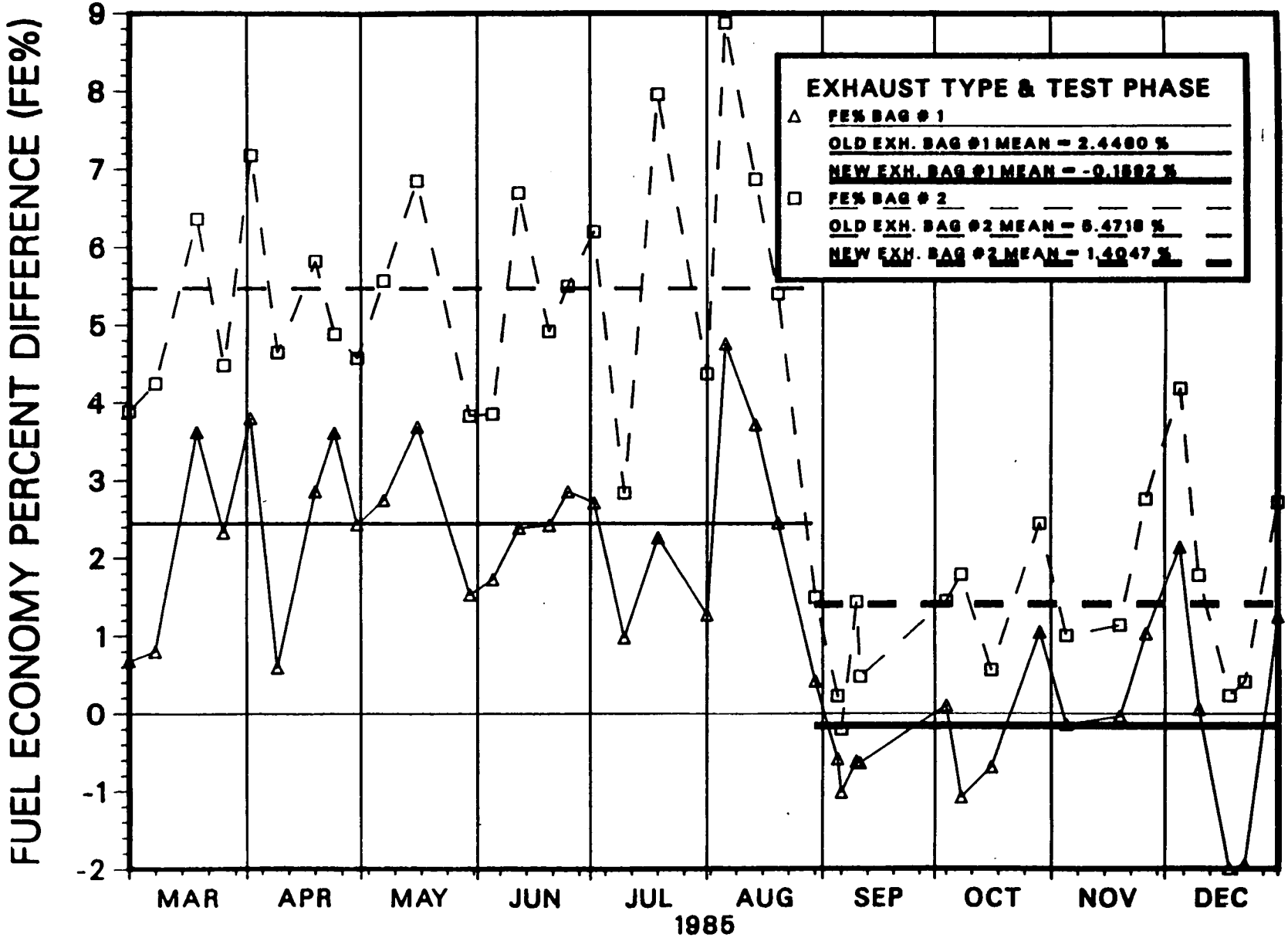
CVS 22C, DYNO D002



VOLVO REPCA FE% CHRONOLOGICALLY

FE%=[(CARB. BAL. FE - METERED FE)/(METERED FE)]*100

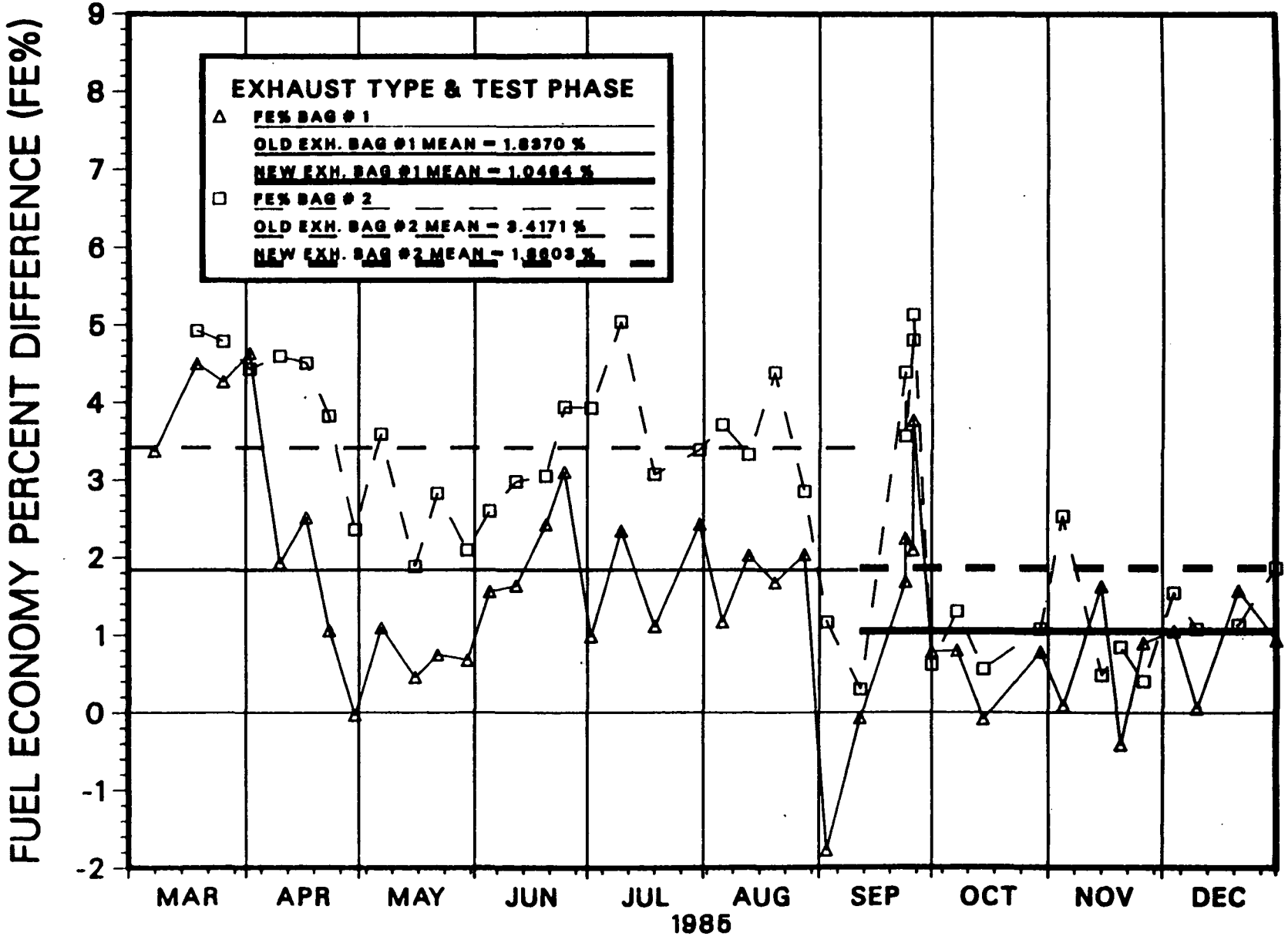
CVS 23C, DYNO D003



VOLVO REPCA FE% CHRONOLOGICALLY

FE%=[(CARB. BAL. FE - METERED FE)/(METERED FE)]*100

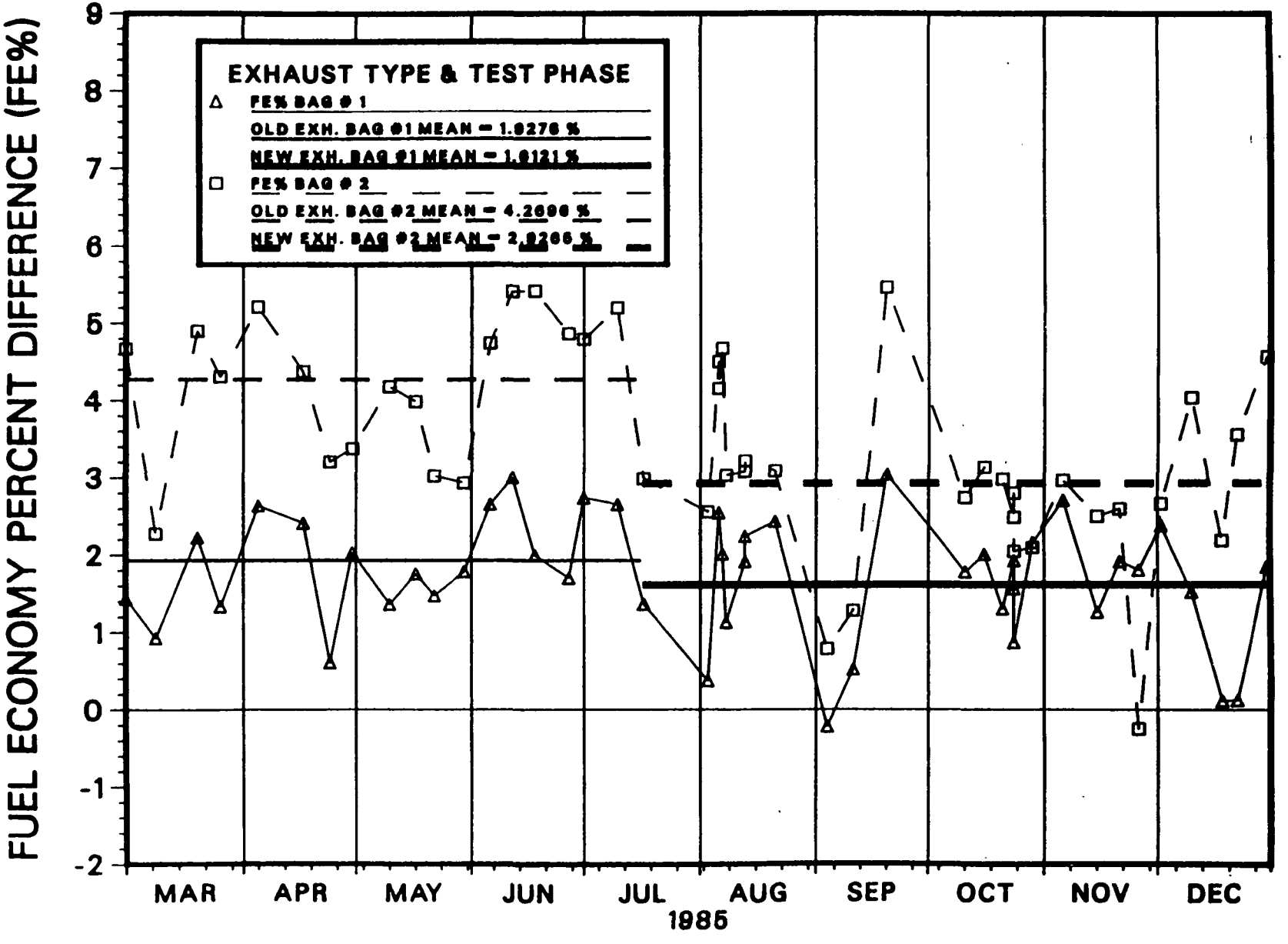
CVS 24C, DYNO D004



VOLVO REPCA FE% CHRONOLOGICALLY

FE%=[(CARB. BAL. FE - METERED FE)/(METERED FE)]*100

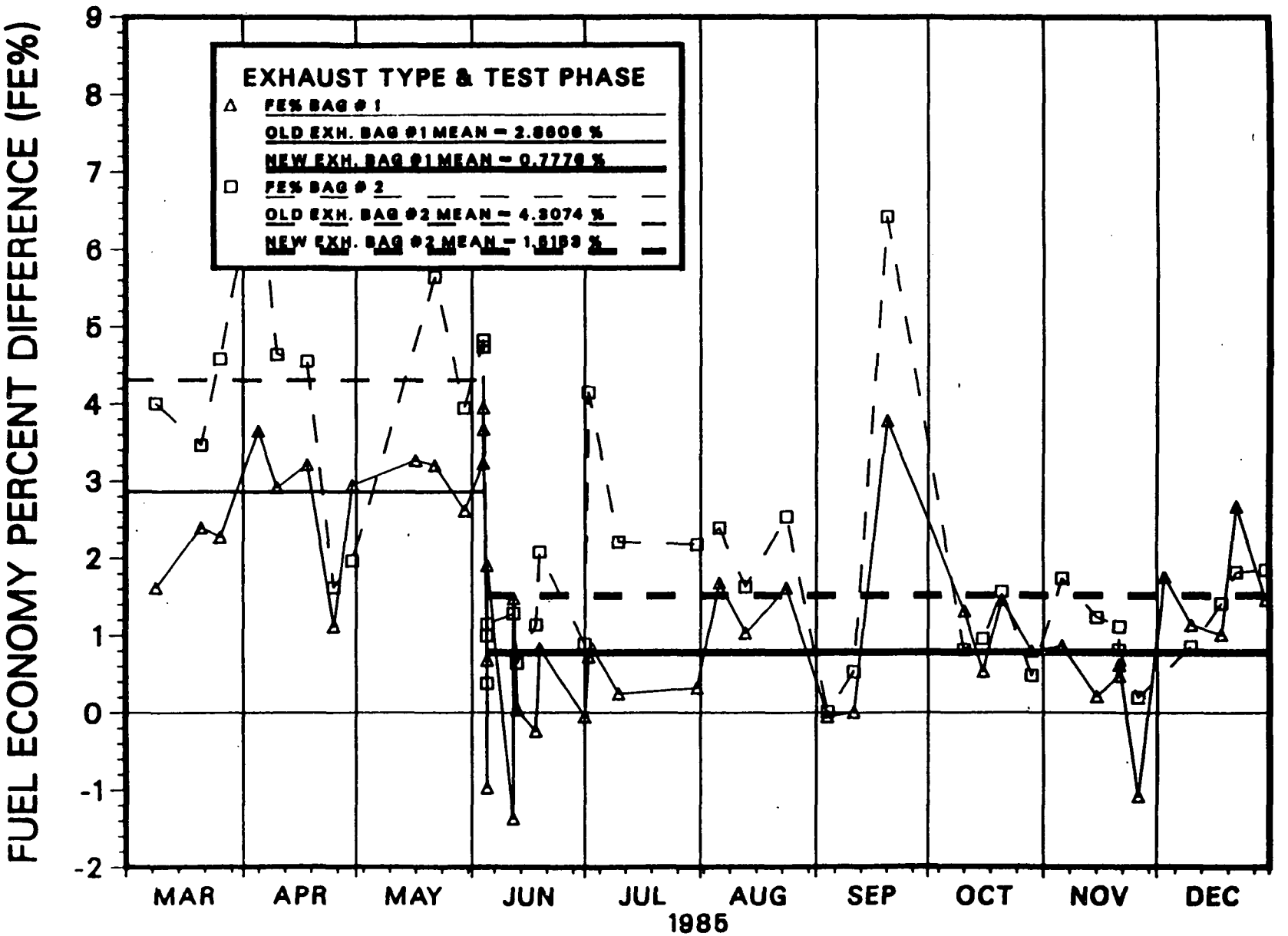
CVS 29C, DYNO D005



VOLVO REPCA FE% CHRONOLOGICALLY

FE%=[(CARB. BAL. FE - METERED FE)/(METERED FE)]*100

CVS 25C, DYNO D006



Volvo REPCA FE% Dynos 1-6
FE% =[(Carb. Bal. FE-Metered FE)/(Metered FE)]*100
March 1,1985 THRU December 31,1985

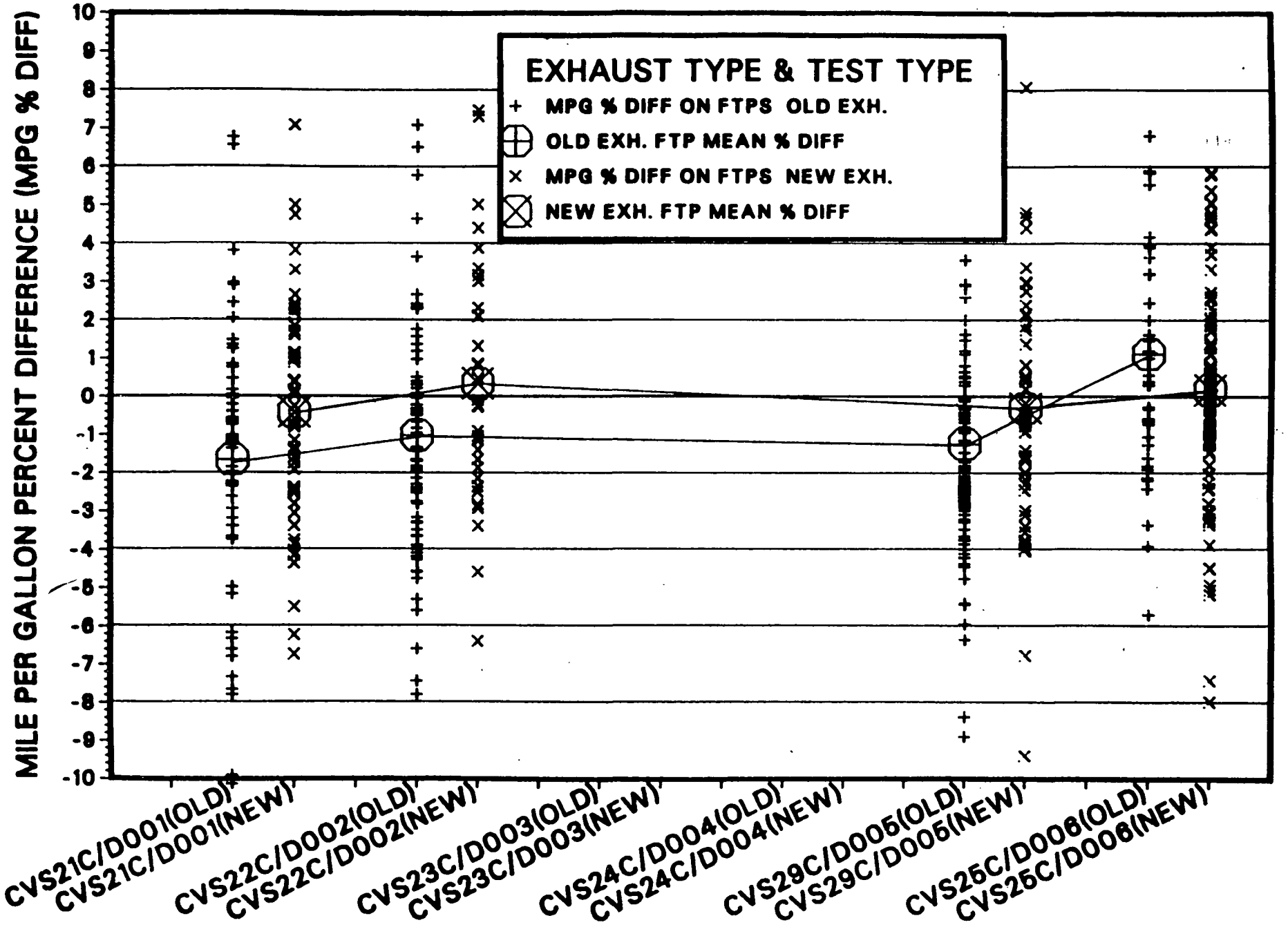
HOT START LA-4'S
Two Bag Weighted Values

CVS/DYNO	Old	New	Shift
21C/D001	+2.44%	+1.68%	-0.76%
22C/D002	+4.21%	+1.56%	-2.65%
23C/D003	+4.06%	+0.58%	-3.48%
24C/D004	+2.65%	+1.48%	-1.17%
29C/D005	+3.09%	+2.31%	-0.78%
25C/D006	+3.65%	+1.13%	-2.52%
Six Dyno Average	+3.35%	+1.46%	-1.89%

PAIRED DATA MPG % DIFF VS TEST SITE(EXHAUST TYPE)

MPG % DIFF=[(MFR MPG-EPA MPG)/(EPA MPG)]*100

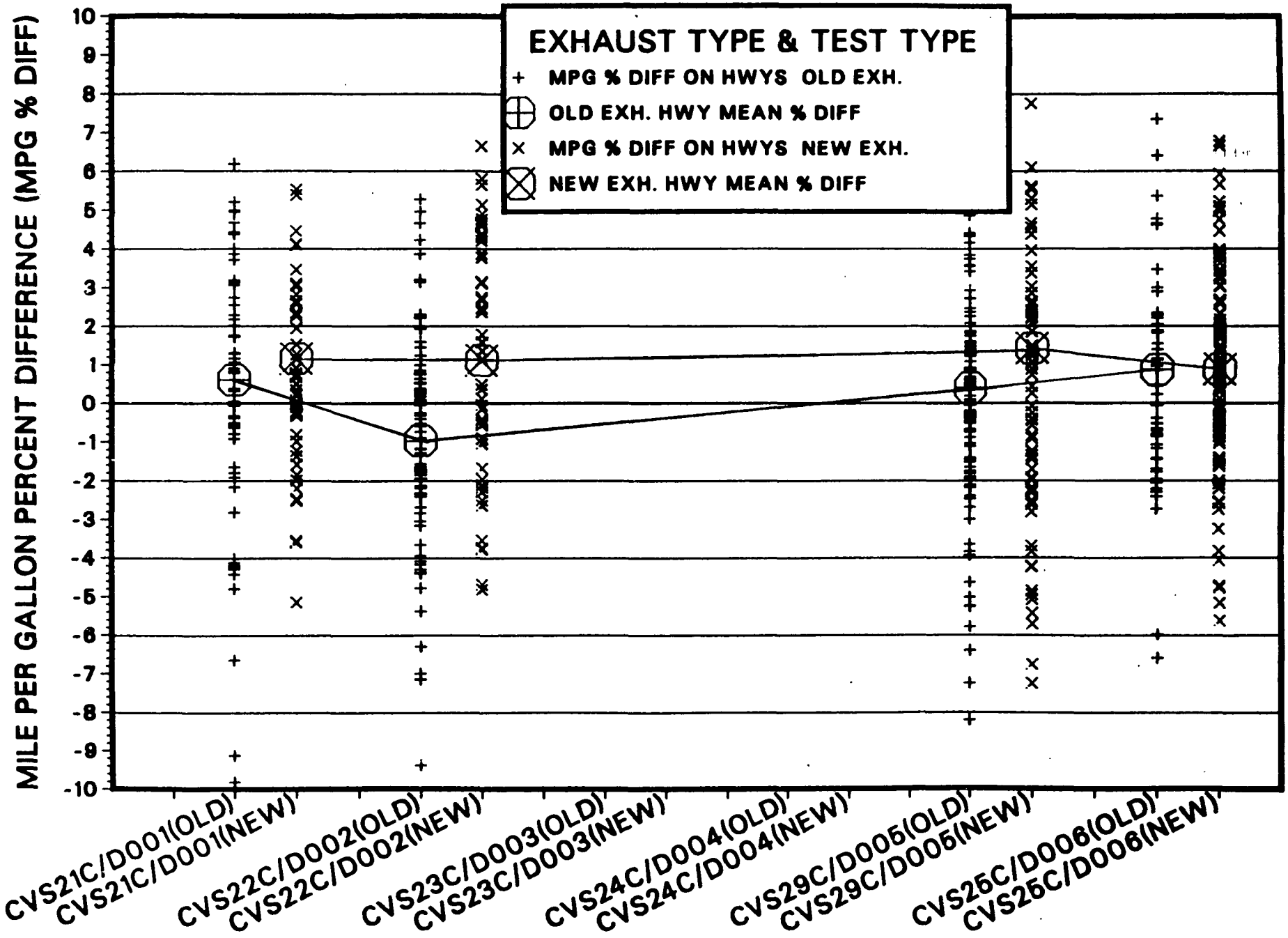
FTP VALUES



PAIRED DATA MPG % DIFF VS TEST SITE(EXHAUST TYPE)

MPG % DIFF=[(MFR MPG-EPA MPG)/(EPA MPG)]*100

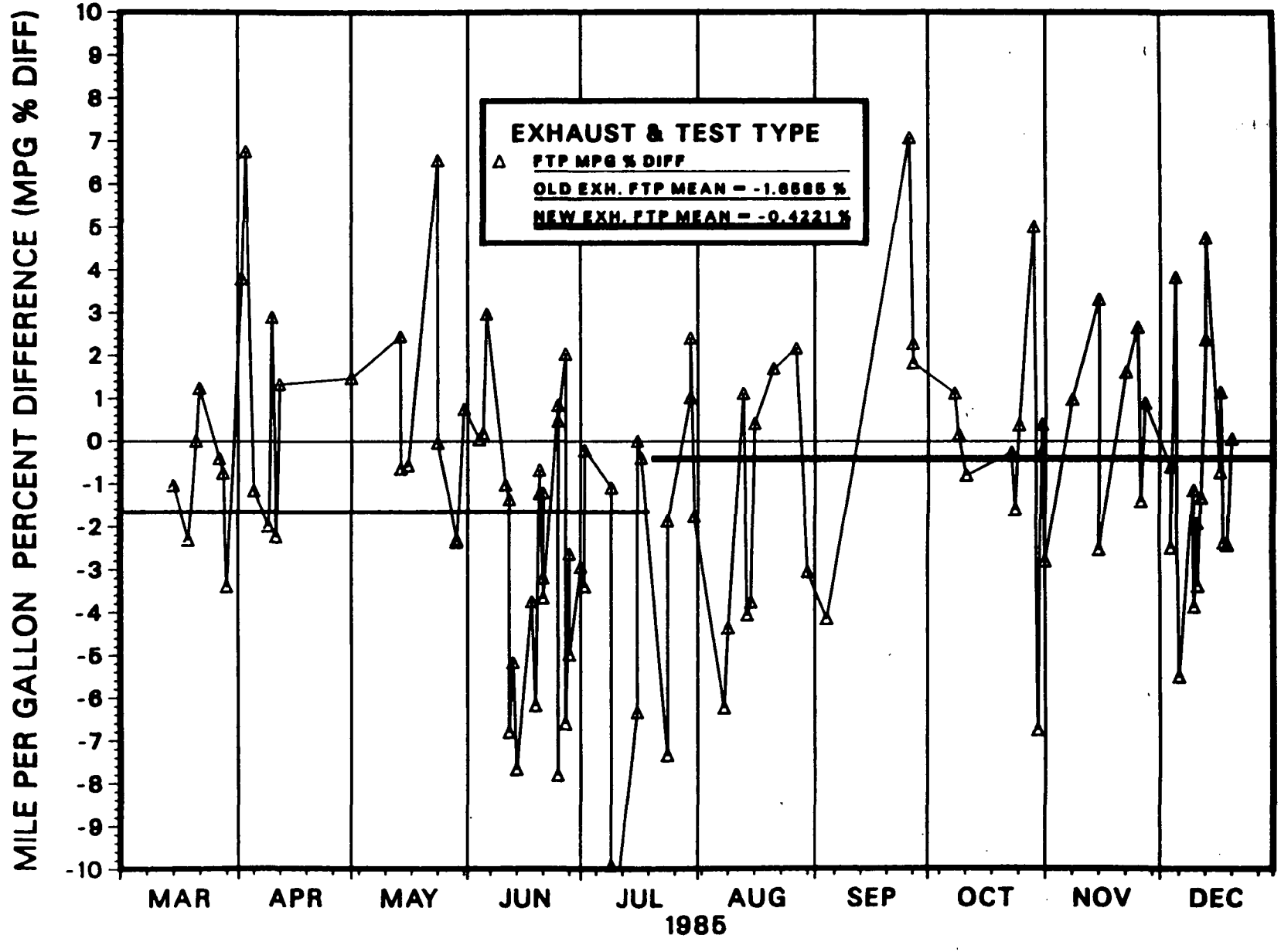
HWY VALUES



FTP PAIRED DATA MPG % DIFF CHRONOLOGICALLY

MPG % DIFF=[(MFR MPG - EPA MPG)/(EPA MPG)]*100

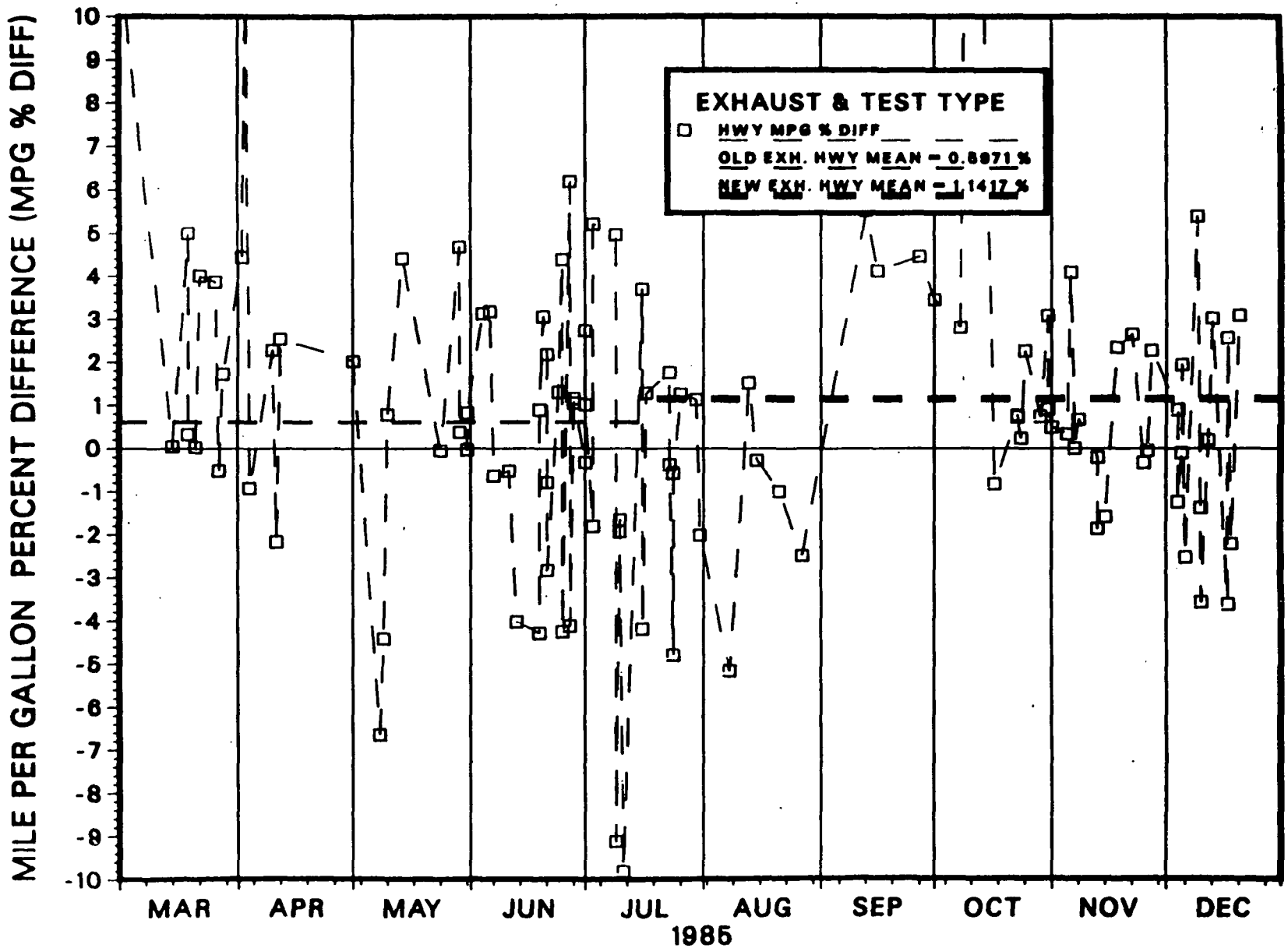
CVS 21C, DYNO D001



HWFET PAIRED DATA MPG % DIFF CHRONOLOGICALLY

MPG % DIFF=[(MFR MPG - EPA MPG)/(EPA MPG)]*100

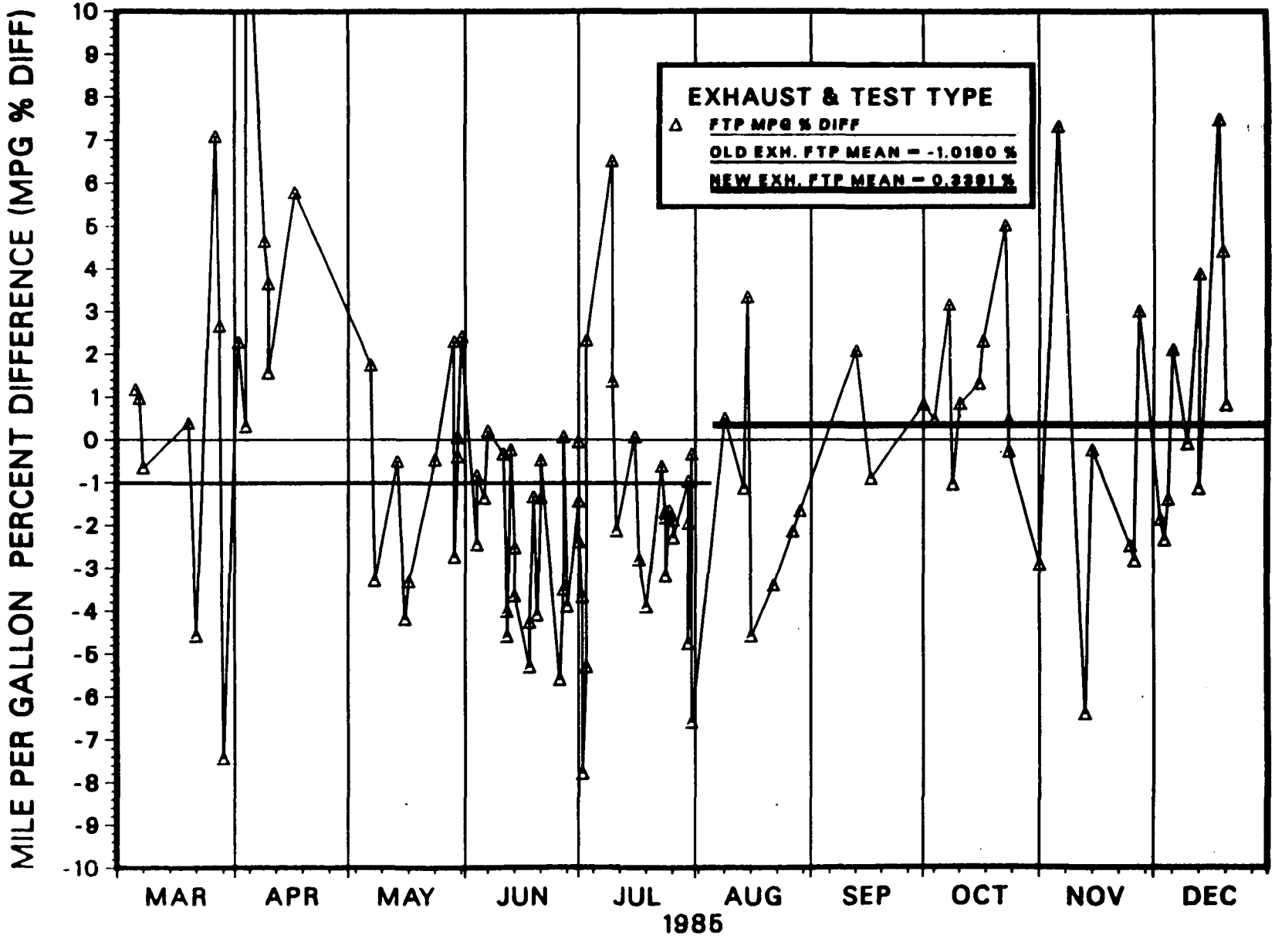
CVS 21C, DYNO D001



FTP PAIRED DATA MPG % DIFF CHRONOLOGICALLY

MPG % DIFF=[(MFR MPG - EPA MPG)/(EPA MPG)]*100

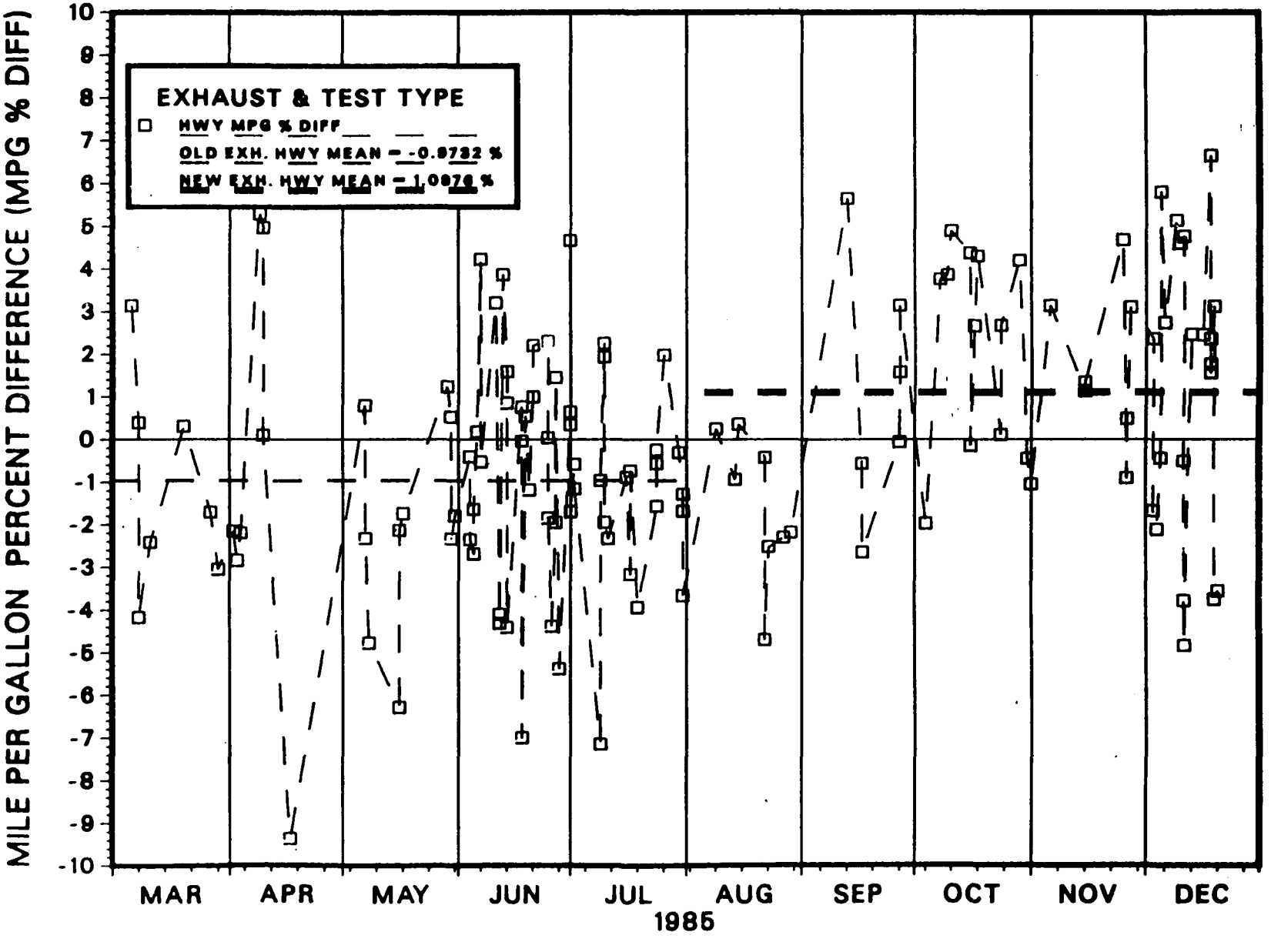
CVS 22C, DYNO D002



HWFET PAIRED DATA MPG % DIFF CHRONOLOGICALLY

MPG % DIFF=[(MFR MPG - EPA MPG)/(EPA MPG)]*100

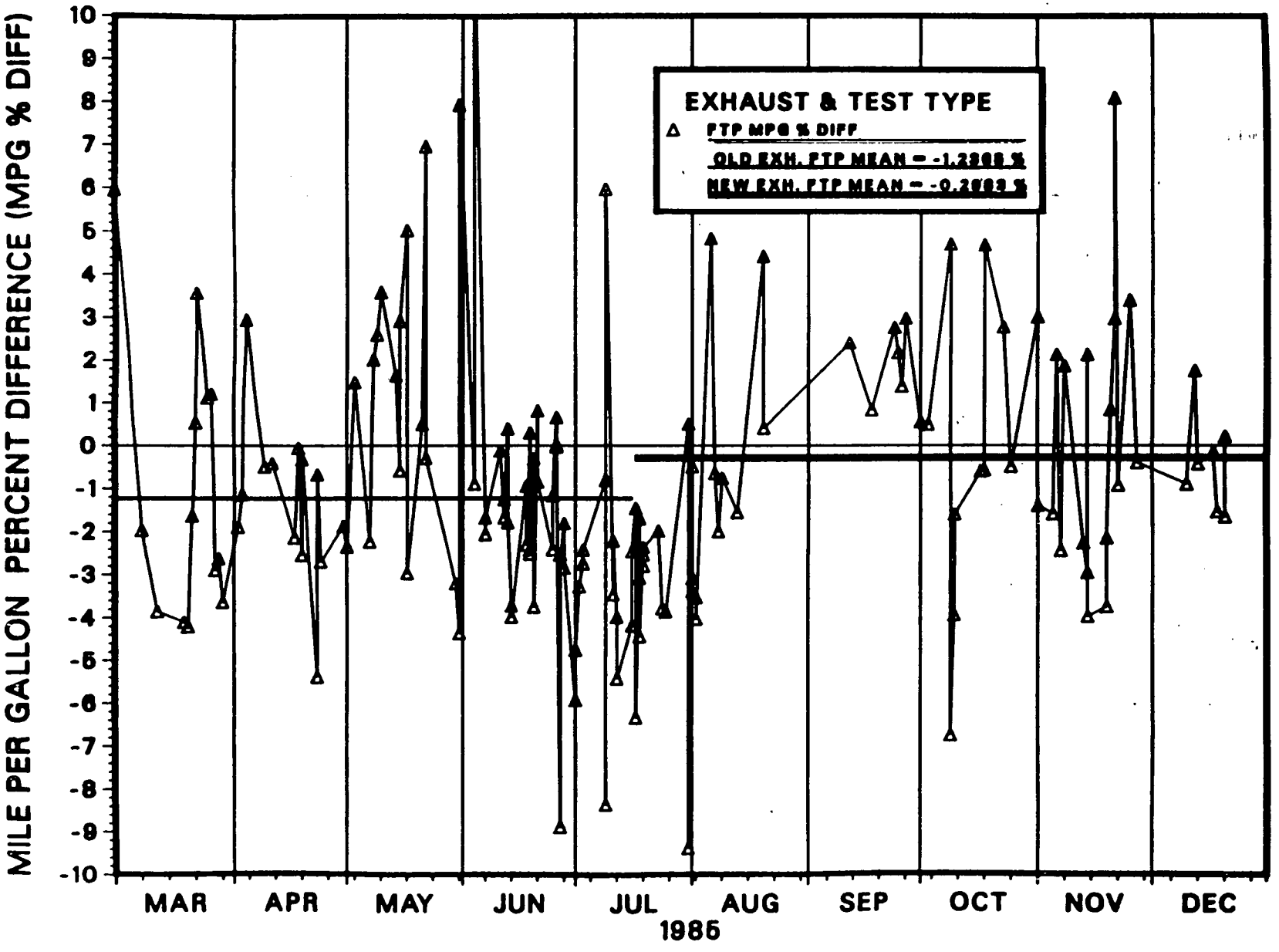
CVS 22C, DYNO D002



FTP PAIRED DATA MPG % DIFF CHRONOLOGICALLY

MPG % DIFF=[(MFR MPG - EPA MPG)/(EPA MPG)]*100

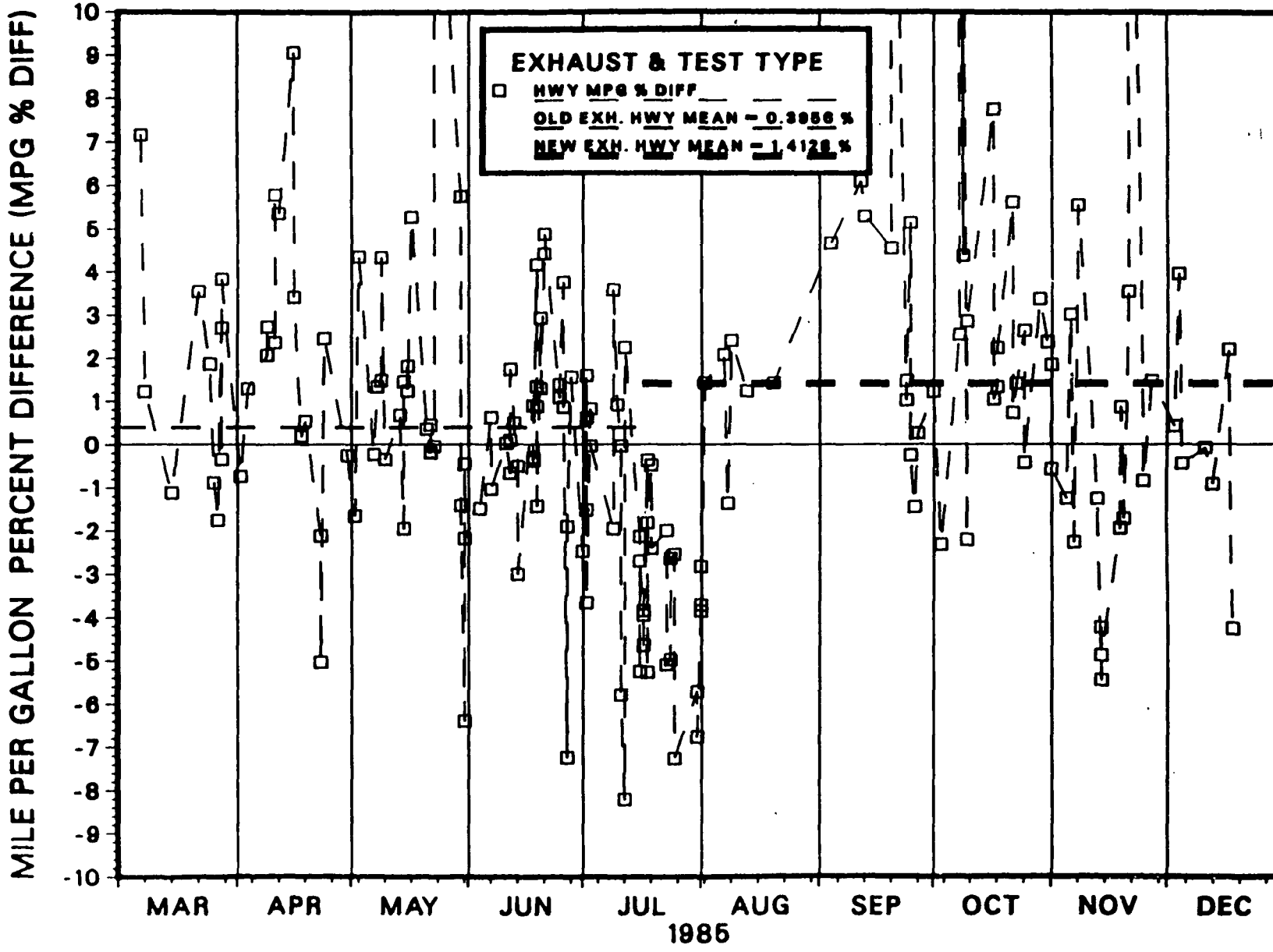
CVS 29C, DYNO D005



HWFET PAIRED DATA MPG % DIFF CHRONOLOGICALLY

MPG % DIFF=[(MFR MPG - EPA MPG)/(EPA MPG)]*100

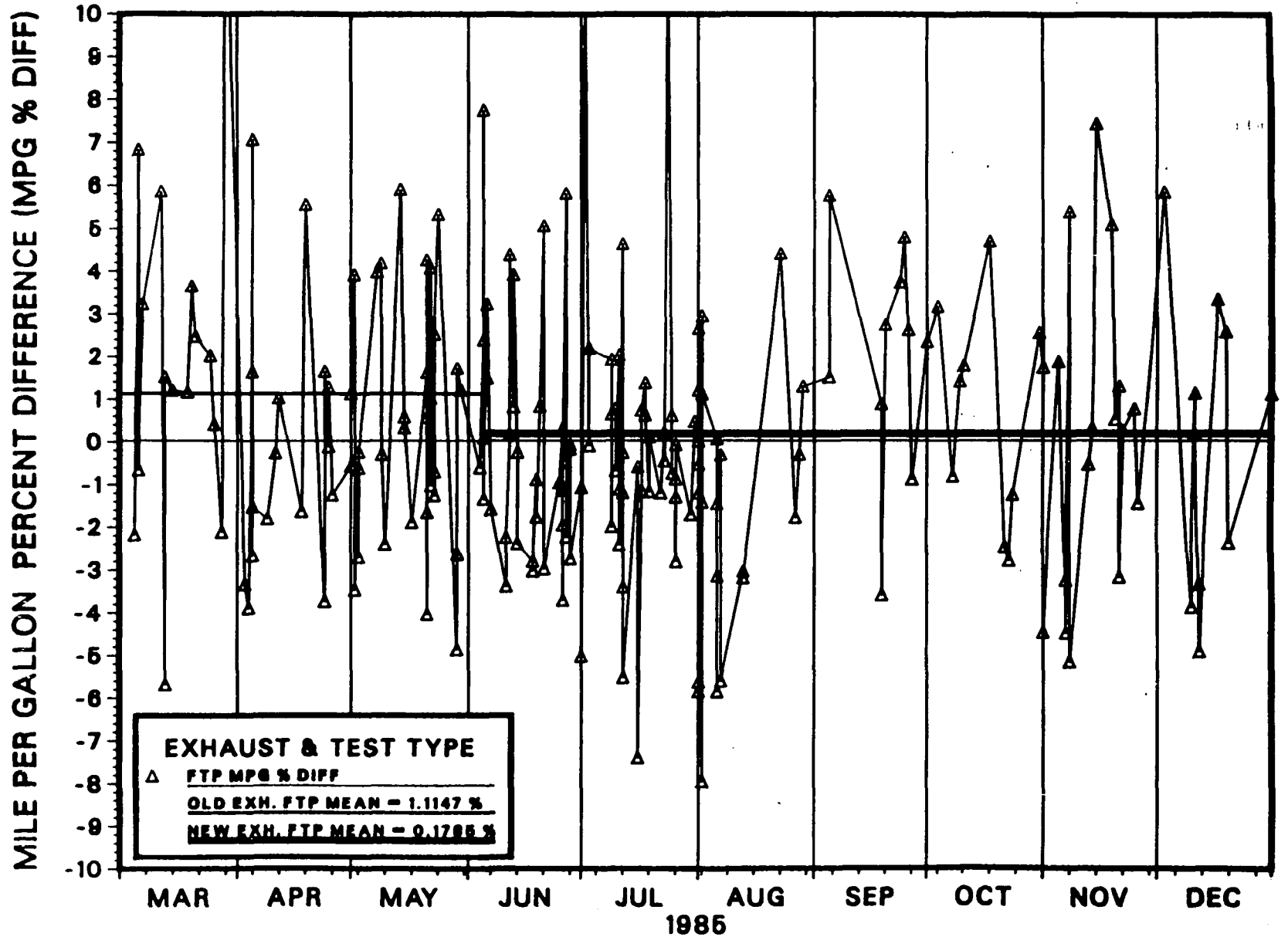
CVS 29C, DYNO D005



FTP PAIRED DATA MPG % DIFF CHRONOLOGICALLY

MPG % DIFF=[(MFR MPG - EPA MPG)/(EPA MPG)]*100

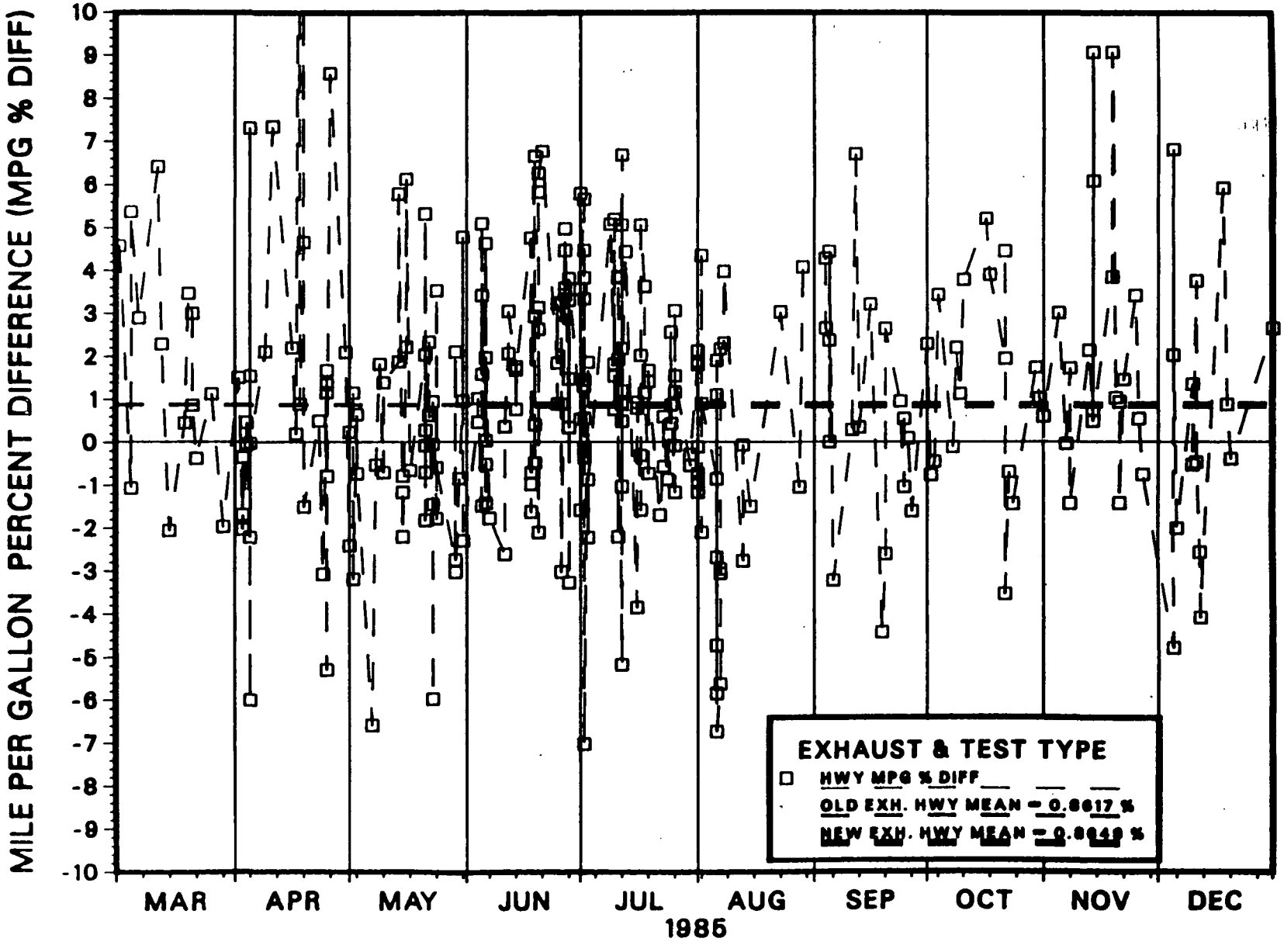
CVS 25C, DYNO D006



HWFET PAIRED DATA MPG % DIFF CHRONOLOGICALLY

MPG % DIFF=[(MFR MPG - EPA MPG)/(EPA MPG)]*100

CVS 25C, DYNO D006



Paired Data Mean MPG % DIFF
MPG % DIFF =
[(MFR MPG - EPA MPG) / (EPA MPG)]*100
March 1,1985 Thru December 31,1985

	FTP			HWY		
CVS/DYNO	Old	New	Shift	Old	New	Shift
21C/D001	-1.66%	-0.42%	+1.24%	+0.60%	+1.14%	+0.54%
22C/D002	-1.02%	+0.34%	+1.36%	-0.97%	+1.10%	+2.07%
29C/D005	-1.24%	-0.30%	+0.94%	+0.40%	+1.41%	+1.02%
25C/D006	+1.11%	+0.18%	-0.94%	+0.86%	+0.86%	+0.00%
Four Dyno Average	-0.70%	-0.06%	+0.65%	+0.22%	+1.13%	+0.91%