EPA-AA-EOD/TPB-85-1

Technical Report

EPA-GM Fuel Economy Correlation Program

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NOTICE

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Background

This test program was initiated in response to GM's request to investigate a negative fuel economy offset between paired test results obtained at the EPA MVEL and at GM's Milford Proving Grounds.

An analysis of the EPA-GM paired certification data did not suggest that the reason for the fuel economy offset was attributable to a particular test site or component of the fuel economy measurement process. Therefore, the structure of the correlation program included tests on multiple dynamometer and analyzer sites at EPA, measurements of dynamometer torque and horsepower, volumetric fuel measurement, and CO_2 bottle crosschecks.

Program Design

Emission and fuel economy tests consisted of a series of three hot start LA-4's on four dynamometers (three analyzer sites) at the EPA and one test site at GM. Volumetric (metered) fuel consumption and wheel torque/horsepower were measured for each dynamometer test at each facility, thereby providing an accurate and direct method of assessing dynamometer loading and vehicle fuel economy repeatibility. The CO_2 gas standards provided a direct check on the CO_2 analyzer calibration differences between test facilities.

The test vehicle was a GM "repeatable" vehicle, a 1984 Pontiac J-2000 with throttle-body fuel injection. The same tank of Howell test fuel was used for the first four tests at GM and EPA, and a second tank was used for the remaining tests. A 15 minute, 50 mph steady state warm-up and the series of three hot start LA-4's served as the preconditioning for the following day of testing.

The actual sequence of dynamometer tests was:

June 17	three	hot	- start	LA-4	tests	at	GM	on	test site No. 8
June 19	"	"	"	"	"	"	EPA	on	dynamometer 001
June 20	"	"	"	"	"	"	EPA	on	" 003
June 21	"	"	"	"	"	"	EPA	on	" 005
June 27	"	"	"	"	"	"	EPA	on	" 006
July 3	"	"	"	"	"	"	EPA	on	" 006
July 24	"	"	"	"	"	"	GM	on	test site No. 8

Each three test series was run on a different day. All tests at the GM were driven by the same GM driver and all tests at the EPA were driven by the same EPA driver.

In addition to the LA-4 tests and CO_2 cylinder analyses, a "wet" sample bag from the test vehicle was generated and analyzed at GM and at three analyzer sites at EPA.

Results

The following test results and observations were obtained from this correlation program:

1. GM average carbon balance fuel economy was 2.2 percent lower than EPA test results.

2. GM metered fuel economy was 0.3 percent lower than EPA metered fuel economy.

3. GM's average CO_2 measurements were 0.3 percent higher than EPA's.

4. Dynamometer loading between facilities was similar.

5. The EPA site-to-site emission and fuel economy repeatibility was good.

6. The fuel economy measured with the new exhaust connector pipe was 0.8 percent lower than the results obtained with the old connector pipe.

Discussion

Table 1 is a summary of the composite LA-4 emission and fuel economy data obtained at the EPA and GM.

The test results labeled EPA D006/2 were repeat tests run on dynamometer D006 after a possible exhaust leak was discovered after the first series of tests. It was not possible to estimate the quantitative impact, if any, of the leak and therefore these results were not removed from the data base, although they are tabulated separately. The GM data were combined because their tests were all run on the same dynamometer/analyzer site, the same driver drove all six tests, and relatively little time elapsed between the first and second set of GM tests.

Table A-1, in the Appendix, is the standard output format of the EPA LABCOR program which calculates the mean, standard deviation, coefficient of variation, and the percent difference between sample means. Percent difference results are referenced to the mean of the tests in the first row, which is the grand mean of all EPA tests.

CO_2 analysis is summarized in Table 2.

Emission and Fuel Economy Results

Figures A-1 - A-19 and Tables A-2 - A-4 of the Appendix present individual phase (bag) 1 and 2 results, and composite results for emissions and fuel economy. Fuel economy calculations are summarized for both metered and carbon balance measurements. Dynamometer torque and horsepower are displayed as positive and negative totals as a function of test phase.

Table 1

Emission and Fuel Economy Results

Test Location	N	HC, g/mi	CO, g/mi	NOx, g/mi	CO_2, g/mi	FE, Mpg
EPA D001	3	x 0.043	1.32	0.52	311	28.3
		s 0.002	0.08	0.03	1.7	0.2
EPA D003	3	x 0.048	1.48	0.51	313	28.2
		s 0.009	0.15	0.02	2.5	0.2
EPA D005	3	x 0.048	1.49	0.53	315	27.9
		s 0.005	0.14	0.04	1.0	0.1
EPA D006/1	3	x 0.059	1.74	0.52	312	28.2
		x 0.005	0.23	0.03	3.0	0.3
EPA D006/2	3	x 0.049	1.58	0.53	313	28.1
		s 0.005	0.16	0.02	1.0	0.1
GM Site 8	6	x 0.053	1.58	0.47	320	27.5
		s 0.003	0.10	0.02	2.7	0.3

Table 2
GM - EPA CO_2 Analysis Correlation

EPA Gas Standards Master Site [1]

Cylinder No.	Reference Type	GM Conc, %	EPA Conc, %	% Difference
LL4381	Facility Master	1.474	1.472	0.14
40321	" "	0.5663	0.5670	-0.12
66753J	Working Master	1.497	1.494	0.20
A3298	" "	1.242	1.240	0.16
277775	" "	0.9505	0.9493	0.13
A12955	" "	0.7495	0.7523	-0.37
A2225	" "	0.4999	0.5005	-0.12
MH932	" "	0.3476	0.3472	0.12

EPA Test Site Analysis [2]

Cylinder No.	GM Conc, %	A001 Conc,%	% Diff	A002 Conc,%	% Diff	A003 Conc,%	% Diff
LL4381	1.474	1.469	0.34	1.470	0.27	1.473	0.07
40321	0.5663	0.5654	0.16	0.5626	0.66	0.5641	0.39

Sample Bag CO_2 Results [3]

EPA Test Site	GM Conc, %	EPA Conc, %	% Difference
A001	12.38	12.45	- 0.6
A002	12.38	12.42	- 0.3
A003	12.38	12.47	- 0.7

NOTE: [1] Analyses on the EPA Master Site were on Range 23, 0-2.5%
[2] Test Site analyses on LL4381 were on Range 23, 0-2.5%
Test Site analyses on 40321 were on Range 22, 0-1%
[3] Bag generated at GM, analyzed at GM Test Site No. 8

Figures A-1 - A-19 are GM "tri-plots". This method of data presentation shows individual test values along the vertical leg of each triangle and plots the mean of the data at the intersection of the other two legs of the triangle. All GM tri-plots display a plus and minus band around the mean of all test results, as in Figures A-1 - A-3, or around the mean of the first three LA-4 tests, as in Figures A-4 - A-19. With the exception of the ± 3.0 percent bands around the carbon balance fuel economy means, the band widths on Figures A-4 - A-19 are somewhat arbitrary and are based on engineering judgment and historical observations of actual emissions data.

Several observations can be made by examining these data. The GM and EPA metered fuel consumption measurements showed good correlation, EPA fuel economy averaged only 0.3 percent higher than GM. Carbon balance fuel economy values were, however, further apart. EPA carbon balance fuel economy averaged 2.2 percent higher than GM results.*

A comparison of Figures A-2 and A-3 shows that the difference between carbon balance and metered fuel economy is larger for phase 2 than phase 1. This observation is consistent with many GM and EPA tests of vehicles equipped with fuel meters and is currently being studied. An analysis of the metered vs carbon balance results shows that the effect of changing to a new style exhaust connector pipe (the old connectors were in place on dynamometers D001, D003, and D005, and the new system was in place on dynamometer D006) was to reduce the difference between carbon balance and volumetric measurements of fuel economy. The table below summarizes these test results. Note that for purposes of this analysis, the first series of tests on dynamometer D006 (tests with a possible exhaust leak) were not used.

Average % Difference Between Carbon Balance and Volumetric Fuel Economy

		EPA Dynamometers			
	n	D001	D003	D005	D006
Bag 1	3	2.3	1.1	1.5	1.6
Bag 2	3	3.8	3.2	3.2	2.0

Note: Values shown are percent differences in fuel economy based on: ((Carbon balance-metered)/(metered)) x 100%

HC and CO emission differences were not apparent and the NO_x differences between facilities shown in Figure A-12 are not thought to be significant. The approximate -10 percent difference (EPA measuring higher NO_x) is likely due to a combination of driver, ambient conditions, and sampling system differences between facilities during the correlation program.

* Although differences are usually expressed using EPA values as the base, this report refers to a number of GM documents which use their results as the base.

Figures A-14 - A-17 summarize the wheel torque data as a function of test site. Positive torque differences (Figures A-14 and A-16) are not significant, based on our in-house test experience with our Volvo REPCA, which is also equipped with torque wheels. Negative torque differences between tests at GM and EPA are shown on Figures A-15 and A-17. Although the tests at GM show 2-4 percent higher negative torque, these difference are not considered significant. Rather, they reflect differences between the GM and EPA drivers and dynamometer frictional horsepower. Clearly, the driver influence is much greater on the measurement of negative torque than positive torque.

Measured distance is presented in Figures A-18 and A-19. Although the first set of distance measurements on EPA dynamometer D006 is clearly higher than the other values, these results are still well within the EPA QC limits for minimum and maximum allowable distance for bag 1 and bag 2.

Tables A-2 - A-4 are data summaries of composite and bag emissions and fuel economy data (measured and carbon balance), torque, horsepower, and distance results. All three tables express the percent difference as (EPA-GM)/GM) x 100 where the reference condition is defined as the average of the first three tests on GM site No. 8.

Gas Analysis

Two GM facility master standards and six working master standards from Milford were analyzed in the EPA gas standards laboratory. The two GM master standards were then analyzed on EPA analyzer sites A001, A002, and A003.

The CO_2 analyses from EPA's gas laboratory showed excellent correlation with GM. The average difference was +0.02 percent for all eight cylinders, while the largest individual difference was -0.37 percent. Gas analyses on sites A001-A003 showed an average difference of +0.32 percent, with all six analyses being slightly positive. Although all readings on sites 1-3 were positive, and thus contribute approximately -0.3 percent to the fuel economy offset, this CO_2 offset is well within the range of good inter-laboratory correlation. The gas analyses are summarized in Table 2.

"Wet" sample bag checks are a diagnostic check used by GM to assess intra-lab analyzer correlation at their laboratory. Wet sample and background bags were generated at GM, analyzed on their site No. 8, and then transported to the EPA laboratory where the bags were read on EPA analyzer sites A001-A003 on June 17. A possible error in the analysis of these bags resulted in deleting the data from further examination. Another wet sample bag was generated and analyzed at GM, and analyzed on all three EPA light-duty analyzer sites. These results are shown in Table 2 and indicate good correlation for this type of crosscheck. Unfortunately, this bag was not reanalyzed by GM to check the CO_2 change as a function of time.

Summary

This program substantiated the 2-3 percent fuel economy offset which has been observed from EPA-GM paired certification data since early 1985. The fuel economy offset is not thought to be attributable to dynamometer loading differences, CO_2 analysis, or ambient effects. Neither is the offset problem confined to a single EPA dynamometer or analyzer site. The results of this program show good EPA site-to-site repeatibility. The change to a new exhaust collection system did not eliminate the fuel economy offset, although a reduction in the difference was observed.

Recommendations for Future Work

1. Concentrate on the sampling system as a possible source of fuel economy offsets between the facilities. This program isolated possible dynamometer and CO_2 analysis differences and did not show significant offsets in either area.

2. Monitor the effect of the EPA CVS plumbing changes on a site by site basis to determine if this change has the anticipated effect of reducing EPA-Mfr paired data scatter, and reducing EPA measurements of carbon balance fuel economy.

APPENDIX A

TABLE A-1

PRJ: GM FE OFFSET — LAB CORRELATION SUMMARY — PROCESSED: AUG 13, 1985

TEST PROCEDURE: HOT VIN: 2E618D INERTIA WT: 2875 ACTUAL HP 6.3

LAB	N		CH4	HC	CO	NOX	CO2	FE	BARO	SHUM	NXFC	CDT	DB	EVAP/AUXILLARY FIELD OPTION		
			<-----G/MI----->					(MPG)	(IN-HG)	(G/LB)				BAG DATA NOT USED		
EPA	15	MEAN	0.025	0.049	1.52	0.52	313.	28.1	29.01	49.6	0.893	0.0	75.3	0.0	0.0	0.0
		STD. DEV.	.0025	.0072	0.195	.025	2.2	0.2	0.09	2.72	0.010	0.0	0.73	0.0	0.0	0.0
		C.V.%	9.9	14.6	12.8	4.8	0.7	0.7	0.32	5.5	1.154	0.0	1.0	0.0	0.0	0.0
EPA DYNO D001	3	MEAN	0.0	0.043	1.32	0.52	311.	28.3	28.90	54.2	0.911	0.0	75.2	0.0	0.0	0.0
		STD. DEV.	.0	.0015	0.075	.029	1.7	0.2	0.026	0.36	0.302	0.0	0.09	0.0	0.0	0.0
		C.V.%	0.0	3.5	5.7	5.6	0.6	0.6	0.09	0.7	0.180	0.0	0.1	0.0	0.0	0.0
		DIFF. %	0.0	-12.2	-13.2	-0.6	-0.6	0.6	-0.4	9.3	2.0	0.0	-0.1	0.0	0.0	0.0
EPA DYNO D003	3	MEAN	0.0	0.048	1.48	0.51	313.	28.2	29.00	46.7	0.883	0.0	76.4	0.0	0.0	0.0
		STD. DEV.	.0	.0087	0.145	.015	2.5	0.2	0.0	0.36	0.002	0.0	0.17	0.0	0.0	0.0
		C.V.%	0.0	18.3	9.8	3.0	0.8	0.7	0.0	0.8	0.186	0.0	0.2	0.0	0.0	0.0
		DIFF. %	0.0	-3.4	-2.9	-2.6	-0.0	0.1	-0.0	-5.9	-1.2	0.0	1.5	0.0	0.0	0.0
EPA DYNO D005	3	MEAN	0.0	0.048	1.49	0.53	315.	27.9	29.00	48.9	0.891	0.0	74.8	0.0	0.0	0.0
		STD. DEV.	.0	.0050	0.137	.042	1.0	0.1	0.0	0.28	0.001	0.0	0.15	0.0	0.0	0.0
		C.V.%	0.0	10.6	9.2	7.9	0.3	0.2	0.0	0.6	0.148	0.0	0.2	0.0	0.0	0.0
		DIFF. %	0.0	-3.4	-2.2	1.3	0.7	-0.7	-0.0	-1.4	-0.3	0.0	-0.7	0.0	0.0	0.0
EPA DYNO D006/1	3	MEAN	0.025	0.059	1.74	0.52	312.	28.2	29.16	49.4	0.893	0.0	74.5	0.0	0.0	0.0
		STD. DEV.	.0025	.0047	0.229	.025	3.0	0.3	0.0	1.34	0.005	0.0	0.26	0.0	0.0	0.0
		C.V.%	9.9	8.0	13.2	4.8	1.0	1.1	0.0	2.7	0.567	0.0	0.3	0.0	0.0	0.0
		DIFF. %	0.0	20.3	14.3	0.6	-0.2	0.1	0.5	-0.3	-0.1	0.0	-1.1	0.0	0.0	0.0
EPA DYNO D006/2	3	MEAN	0.0	0.049	1.58	0.53	313.	28.1	29.00	48.7	0.890	0.0	75.7	0.0	0.0	0.0
		STD. DEV.	.0	.0050	0.164	.023	1.0	0.1	0.026	1.70	0.006	0.0	0.32	0.0	0.0	0.0
		C.V.%	0.0	10.3	10.4	4.4	0.3	0.4	0.09	3.5	0.718	0.0	0.4	0.0	0.0	0.0
		DIFF. %	0.0	-1.4	3.9	1.3	0.1	-0.1	-0.0	-1.8	-0.4	0.0	0.5	0.0	0.0	0.0
GENERAL MOTORS	6	MEAN	0.0	0.053	1.58	0.47	320.	27.5	28.68	49.8	0.894	0.0	76.9	0.0	0.0	0.0
		STD. DEV.	.0	.0028	0.102	.018	2.7	0.3	0.146	0.76	0.003	0.0	0.20	0.0	0.0	0.0
		C.V.%	0.0	5.2	6.4	3.9	0.8	0.9	0.51	1.5	0.329	0.0	0.3	0.0	0.0	0.0
		DIFF. %	0.0	7.4	3.9	-9.3	2.3	-2.3	-1.1	0.5	0.1	0.0	2.1	0.0	0.0	0.0

C.V.% IS THE COEFFICIENT OF VARIATION. ((STD. DEV./MEAN) *100).

DIFF.% IS THE DIFFERENCE OF THE MEANS BETWEEN THE MFR AND EPA LABS. (((MFR-EPA)/EPA) * 100).

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2E618D PONTIAC SUNBIRD

Table A-2

SITE	SEQNO	HC	CO	NOx	CO2	CB/MPG	M/MPG	PHS1MPG	MPHS1MPG	PHS2MPG	MPHS2MPG
8.000	1.000	0.055	1.630	0.450	323.0	27.20	27.28	28.59	28.49	26.14	26.08
8.000	2.000	0.051	1.480	0.470	323.0	27.20	27.23	28.51	28.49	26.15	25.97
8.000	3.000	0.057	1.670	0.490	320.0	27.50	27.47	28.70	28.75	26.42	26.19
MEAN		0.054	1.593	0.470	322.0	27.30	27.33	28.60	28.58	26.24	26.08
STD.DEV.		0.003	0.100	0.020	1.732	0.173	0.124	0.095	0.148	0.159	0.108
1.000	4.000	0.042	1.240	0.500	313.0	28.10	27.54	29.20	28.64	27.30	26.44
1.000	5.000	0.045	1.390	0.500	310.0	28.40	27.60	29.70	28.97	27.30	26.24
1.000	6.000	0.043	1.330	0.550	310.0	28.40	27.57	29.70	28.98	27.20	26.16
MEAN		0.043	1.320	0.517	311.0	28.30	27.57	29.53	28.86	27.27	26.28
STD.DEV.		0.002	0.075	0.029	1.732	0.173	0.033	0.289	0.194	0.058	0.144
% DIFF		-20.25	-17.15	9.929	-3.416	3.663	0.889	3.263	1.004	3.926	0.766
3.000	7.000	0.038	1.330	0.520	315.0	28.00	27.63	28.90	28.81	27.10	26.44
3.000	8.000	0.050	1.480	0.490	313.0	28.10	27.49	29.10	28.67	27.20	26.31
3.000	9.000	0.055	1.620	0.510	310.0	28.40	27.60	29.30	28.80	27.40	26.39
MEAN		0.048	1.477	0.507	312.7	28.17	27.57	29.10	28.76	27.23	26.38
STD.DEV.		0.009	0.145	0.015	2.517	0.208	0.071	0.200	0.077	0.153	0.068
% DIFF		-12.27	-7.322	7.801	-2.899	3.175	0.892	1.748	0.645	3.799	1.162
5.000	10.00	0.043	1.340	0.480	316.0	27.90	27.50	28.90	28.74	27.00	26.27
5.000	11.00	0.053	1.610	0.540	315.0	27.90	27.33	29.10	28.57	26.90	26.10
5.000	12.00	0.047	1.510	0.560	314.0	28.00	27.36	29.10	28.55	27.10	26.17
MEAN		0.048	1.487	0.527	315.0	27.93	27.40	29.03	28.62	27.00	26.18
STD.DEV.		0.005	0.137	0.042	1.000	0.058	0.090	0.115	0.101	0.100	0.087
% DIFF		-12.27	-6.695	12.06	-2.174	2.320	0.265	1.515	0.152	2.909	0.390
6.000	13.00	0.063	1.630	0.520	315.0	27.90	27.56	28.70	28.80	27.30	26.32
6.000	14.00	0.054	1.580	0.500	309.0	28.50	27.56	29.80	28.90	27.40	26.23
6.000	15.00	0.061	2.000	0.550	312.0	28.10	27.52	28.90	28.77	27.50	26.27
MEAN		0.059	1.737	0.523	312.0	28.17	27.55	29.13	28.82	27.40	26.27
STD.DEV.		0.005	0.229	0.025	3.000	0.306	0.023	0.586	0.066	0.100	0.047
% DIFF		9.202	8.996	11.35	-3.106	3.175	0.801	1.865	0.864	4.434	0.746
6.000	16.00	0.044	1.540	0.540	314.0	28.00	27.73	29.40	29.11	26.80	26.35
6.000	17.00	0.048	1.440	0.500	313.0	28.10	27.72	29.50	29.00	26.90	26.45
6.000	18.00	0.054	1.760	0.540	312.0	28.20	27.66	29.60	29.01	27.00	26.31
MEAN		0.049	1.580	0.527	313.0	28.10	27.71	29.50	29.04	26.90	26.37
STD.DEV.		0.005	0.164	0.023	1.000	0.100	0.039	0.100	0.061	0.100	0.070
% DIFF		-10.43	-0.837	12.06	-2.795	2.930	1.384	3.147	1.627	2.528	1.118
8.000	34.00	0.050	1.600	0.480	317.0	27.70	27.78	29.32	29.20	26.38	26.36
8.000	35.00	0.051	1.430	0.450	317.0	27.80	27.69	29.12	29.06	26.58	26.33
8.000	36.00	0.054	1.670	0.490	319.0	27.60	27.45	28.88	28.74	26.41	26.17
MEAN		0.052	1.567	0.473	317.7	27.70	27.64	29.11	29.00	26.46	26.29
STD.DEV.		0.002	0.123	0.021	1.155	0.100	0.169	0.220	0.233	0.108	0.105
% DIFF		-4.908	-1.674	0.709	-1.346	1.465	1.151	1.772	1.476	0.839	0.796

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2E618D PONTIAC SUNBIRD

Table A-3

SITE	PHS1HC	PHS1CO	PHS1NOx	PHS1CO2	PHS2HC	PHS2CO	PHS2NOx	PHS2CO2	BAROM	HUMID	TESTEMP
8.000	0.124	4.550	1.554	1108.	0.287	7.606	1.781	1297.	96.70	50.45	77.00
8.000	0.137	4.912	1.566	1109.	0.240	6.114	1.974	1300.	96.69	50.49	77.00
8.000	0.156	5.583	1.612	1100.	0.266	6.838	2.044	1285.	96.63	50.17	77.00
MEAN	0.139	5.015	1.577	1106.	0.264	6.853	1.933	1294.	96.67	50.37	77.00
STD.DEV.	0.016	0.524	0.031	5.173	0.024	0.746	0.136	7.900	0.038	0.174	
1.000	0.120	4.230	1.720	1083.	0.200	5.060	2.000	1253.	97.87	54.00	75.10
1.000	0.130	4.530	1.760	1056.	0.200	5.800	1.980	1247.	97.87	54.00	75.20
1.000	0.130	4.480	1.930	1052.	0.190	5.350	2.130	1250.	97.87	54.60	75.30
MEAN	0.127	4.413	1.803	1064.	0.197	5.403	2.037	1250.	97.87	54.20	75.20
STD.DEV.	0.006	0.161	0.112	17.29	0.006	0.373	0.081	2.890	0.000	0.346	0.100
% DIFF	-8.873	-12.00	14.33	-3.800	-25.60	-21.15	5.363	-3.408	1.238	7.604	-2.338
3.000	0.110	5.190	1.830	1084.	0.170	4.750	2.070	1267.	98.24	47.10	76.50
3.000	0.160	5.320	1.790	1076.	0.220	5.730	1.870	1254.	98.20	46.40	76.50
3.000	0.190	6.060	1.970	1072.	0.220	6.030	1.800	1245.	98.20	46.60	76.20
MEAN	0.153	5.523	1.863	1077.	0.203	5.503	1.913	1255.	98.21	46.70	76.40
STD.DEV.	0.040	0.469	0.095	6.233	0.029	0.669	0.140	11.30	0.023	0.361	0.173
% DIFF	10.31	10.14	18.13	-2.558	-23.08	-19.69	-1.017	-3.001	1.593	-7.286	-0.779
5.000	0.100	4.500	1.790	1088.	0.220	5.450	1.780	1260.	98.24	48.60	74.60
5.000	0.160	5.140	1.840	1077.	0.240	6.840	2.160	1267.	98.20	48.90	74.90
5.000	0.140	5.100	1.930	1079.	0.210	6.170	2.240	1267.	98.20	49.10	74.80
MEAN	0.133	4.913	1.853	1081.	0.223	6.153	2.060	1265.	98.21	48.87	74.77
STD.DEV.	0.031	0.359	0.071	5.727	0.015	0.695	0.246	3.904	0.023	0.252	0.153
% DIFF	-4.077	-2.027	17.50	-2.207	-15.51	-10.21	6.570	-2.278	1.593	-2.985	-2.900
6.000	0.220	6.120	1.840	1109.	0.260	6.130	2.080	1261.	98.78	50.60	74.80
6.000	0.140	4.910	1.770	1067.	0.260	6.950	1.980	1256.	98.75	49.80	74.40
6.000	0.180	7.320	1.960	1107.	0.280	7.830	2.210	1259.	98.71	48.00	74.30
MEAN	0.180	6.117	1.857	1094.	0.267	6.970	2.090	1259.	98.75	49.47	74.50
STD.DEV.	0.040	1.205	0.096	23.43	0.012	0.850	0.115	2.193	0.035	1.332	0.265
% DIFF	29.50	21.97	17.71	-1.022	0.883	1.712	8.122	-2.734	2.145	-1.793	-3.247
6.000	0.110	5.160	2.010	1078.	0.220	6.360	2.020	1280.	98.27	49.90	75.90
6.000	0.140	4.640	1.700	1068.	0.220	6.080	2.020	1262.	98.20	49.50	75.80
6.000	0.170	6.270	1.900	1060.	0.230	6.790	2.120	1259.	98.17	46.80	75.30
MEAN	0.140	5.357	1.870	1069.	0.223	6.410	2.053	1267.	98.21	48.73	75.67
STD.DEV.	0.030	0.833	0.157	9.127	0.006	0.358	0.058	11.02	0.051	1.686	0.321
% DIFF	0.719	6.813	18.55	-3.343	-15.51	-6.460	6.225	-2.102	1.593	-3.249	-1.732
8.000	0.110	5.002	1.523	1079.	0.260	6.934	2.027	1287.	97.62	48.98	77.00
8.000	0.139	4.992	1.563	1086.	0.241	5.681	1.815	1278.	97.60	48.99	76.50
8.000	0.152	5.794	1.664	1096.	0.247	6.642	1.998	1286.	97.56	49.35	77.00
MEAN	0.134	5.263	1.583	1087.	0.249	6.419	1.947	1284.	97.59	49.11	76.83
STD.DEV.	0.022	0.460	0.073	8.320	0.010	0.656	0.115	4.782	0.031	0.211	0.289
% DIFF	-3.837	4.939	0.380	-1.697	-5.675	-6.328	0.707	-0.798	0.952	-2.508	-0.216

EPA/M-VEL HOT START CORRELATION - SUMMER '85
2E618D PONTIAC SUNBIRD

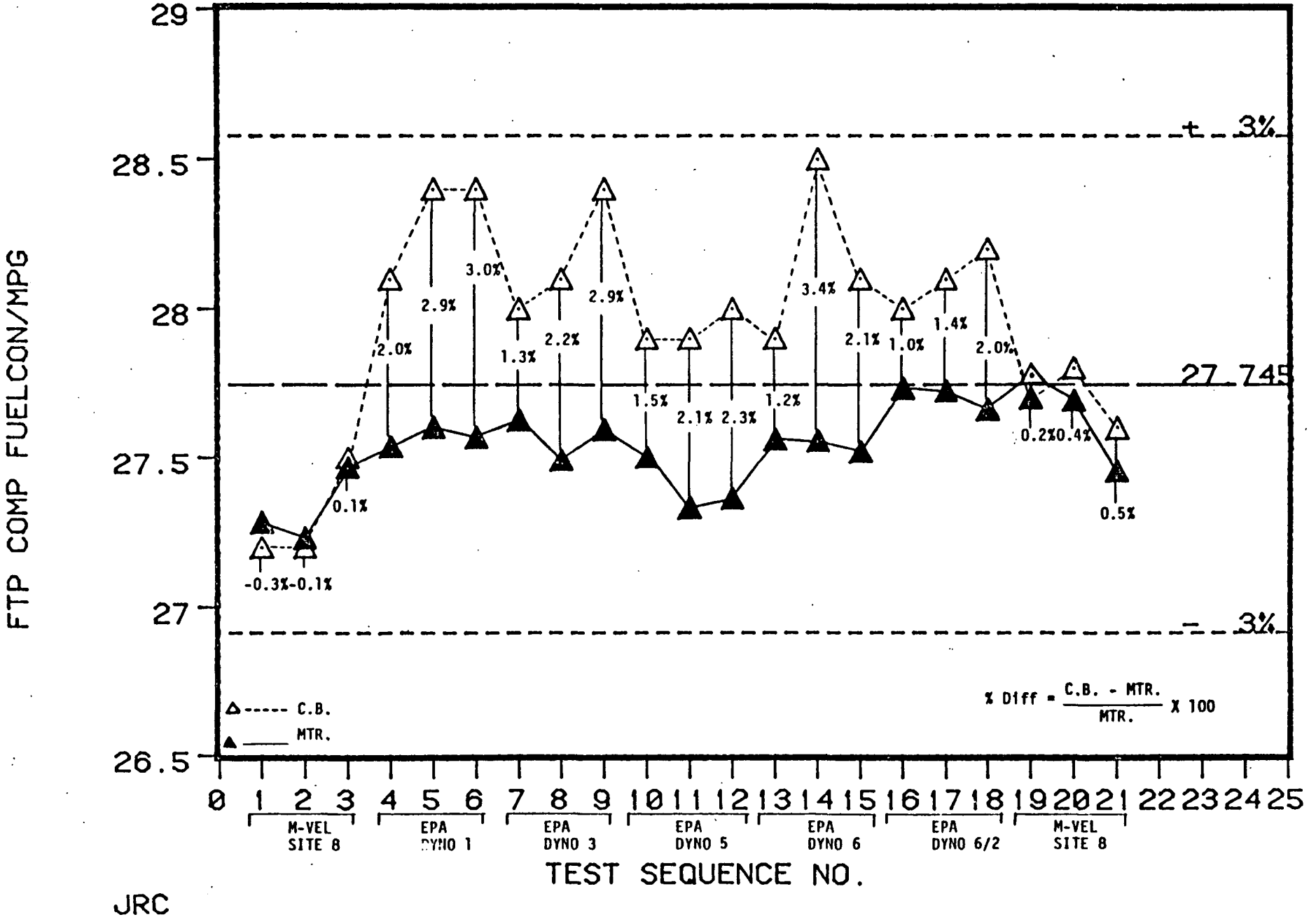
Table A-4

SITE	PH1PTORQ	PH1NTORQ	PH2PTORQ	PH2NTORQ	POS/Hp1	NEG/Hp1	POS/Hp2	NEG/Hp2	PHS1DIST	PHS2DIST	ROLL/Ft1	ROLL/Ft2
8.000	4269.	2151.	6686.	3739.	2629.	889.7	2508.	1113.	3.596	3.861	18786	20290
8.000	4332.	2126.	6713.	3785.	2675.	886.2	2521.	1130.	3.592	3.864	18772	20301
8.000	4330.	2133.	6732.	3759.	2689.	888.7	2527.	1114.	3.589	3.863	18757	20295
MEAN	4310.	2136.	6710.	3761.	2665.	888.2	2519.	1119.	3.592	3.863	18772	20295
STD.DEV.	36.04	12.85	22.96	23.02	31.25	1.803	9.805	9.535	0.004	0.002	14.65	5.735
1.000	4261.	2130.	6582.	3697.	2697.	787.4	2546.	1021.	3.587	3.878	18094	20462
1.000	4282.	2088.	6570.	3730.	2711.	785.1	2528.	1011.	3.562	3.869	18761	20431
1.000	4290.	2059.	6561.	3682.	2699.	773.0	2503.	994.4	3.550	3.863	18692	20384
MEAN	4278.	2092.	6571.	3703.	2702.	781.8	2526.	1009.	3.566	3.870	18782	20426
STD.DEV.	15.30	35.62	10.40	24.18	7.814	7.736	21.57	13.35	0.019	0.008	103.1	39.39
% DIFF	-0.749	-2.064	-2.072	-1.532	1.424	-11.98	0.282	-9.870	-0.724	0.190	0.057	0.643
3.000	4284.	2090.	6738.	3682.	2706.	789.5	2604.	1020.	3.565	3.897	18752	20549
3.000	4385.	2132.	6748.	3735.	2783.	804.4	2633.	1054.	3.563	3.881	18733	20467
3.000	4389.	2112.	6715.	3693.	2788.	792.9	2598.	1029.	3.579	3.883	18815	20471
MEAN	4353.	2111.	6734.	3703.	2759.	795.6	2612.	1034.	3.569	3.887	18767	20495
STD.DEV.	59.42	21.31	16.92	27.65	45.72	7.808	18.49	17.36	0.009	0.009	43.14	46.30
% DIFF	0.988	-1.170	0.352	-1.524	3.542	-10.43	3.679	-7.592	-0.650	0.630	-0.026	0.986
5.000	4297.	2060.	6731.	3623.	2717.	759.7	2593.	982.0	3.571	3.867	18784	20390
5.000	4404.	2065.	6757.	3713.	2770.	776.9	2610.	1018.	3.558	3.879	18711	20449
5.000	4326.	2093.	6693.	3693.	2750.	789.0	2602.	1024.	3.567	3.899	18759	20557
MEAN	4342.	2072.	6727.	3676.	2746.	775.2	2602.	1008.	3.565	3.882	18751	20465
STD.DEV.	55.22	18.00	31.77	47.08	26.95	14.72	8.402	22.77	0.007	0.016	37.34	84.52
% DIFF	0.742	-2.999	0.253	-2.248	3.042	-12.72	3.286	-9.927	-0.752	0.492	-0.107	0.837
6.000	4254.	2126.	6650.	3730.	2717.	800.8	2586.	999.3	3.621	3.910	19113	20662
6.000	4338.	2105.	6680.	3684.	2774.	800.0	2600.	1010.	3.612	3.913	19062	20679
6.000	4359.	2117.	6723.	3754.	2810.	818.2	2650.	1040.	3.647	3.946	19252	20850
MEAN	4317.	2116.	6685.	3722.	2767.	806.3	2612.	1017.	3.627	3.923	19142	20730
STD.DEV.	55.64	10.41	36.56	35.62	46.62	10.28	34.14	21.24	0.018	0.020	98.15	104.1
% DIFF	0.157	-0.955	-0.379	-1.025	3.849	-9.217	3.692	-9.167	0.956	1.562	1.976	2.143
6.000	4255.	2106.	6616.	3609.	2703.	778.9	2564.	987.6	3.607	3.895	19010	20557
6.000	4249.	2092.	6557.	3724.	2672.	789.4	2524.	1029.	3.575	3.866	18839	20404
6.000	4292.	2174.	6597.	3675.	2720.	809.4	2540.	1021.	3.571	3.862	18817	20382
MEAN	4265.	2124.	6590.	3670.	2698.	792.6	2543.	1012.	3.584	3.874	18888	20448
STD.DEV.	23.09	43.99	30.18	57.48	24.61	15.49	20.44	21.83	0.020	0.018	105.8	95.49
% DIFF	-1.044	-0.590	-1.792	-2.426	1.261	-10.77	0.941	-9.543	-0.223	0.302	0.623	0.752
8.000	4213.	2179.	6577.	3867.	2570.	900.2	2461.	1133.	3.594	3.865	18756	20286
8.000	4259.	2212.	6605.	3791.	2627.	892.5	2479.	1136.	3.595	3.861	18761	20253
8.000	4305.	2188.	6646.	3799.	2666.	902.7	2500.	1139.	3.598	3.862	18796	20274
MEAN	4259.	2193.	6609.	3819.	2621.	898.5	2480.	1136.	3.596	3.863	18771	20271
STD.DEV.	45.90	16.86	34.52	41.91	47.94	5.316	19.91	3.100	0.002	0.002	21.73	16.65
% DIFF	-1.182	2.645	-1.503	1.549	-1.639	1.156	-1.543	1.474	0.093	0.000	-0.003	-0.119

EPA/M-VEL CORRELATION - SUMMER '85

PONTIAC SUNBIRD 2E618D - HOT START

Figure A-1



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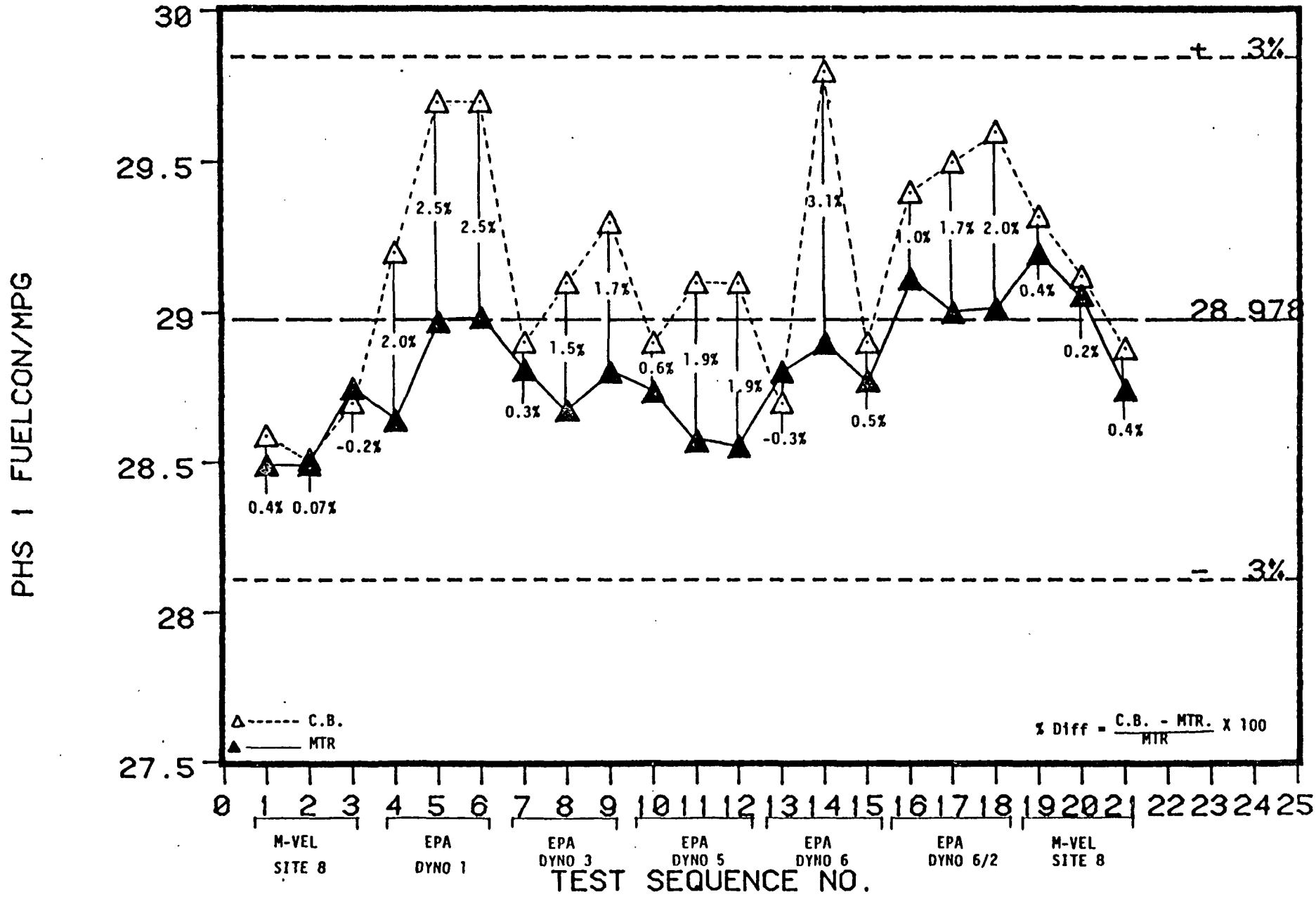
24JL85

EPA/M-VEL CORRELATION - SUMMER '85

PONTIAC SUNBIRD 2E618D - HOT START

Figure A-2



JRC
24JL85

Figure A-3

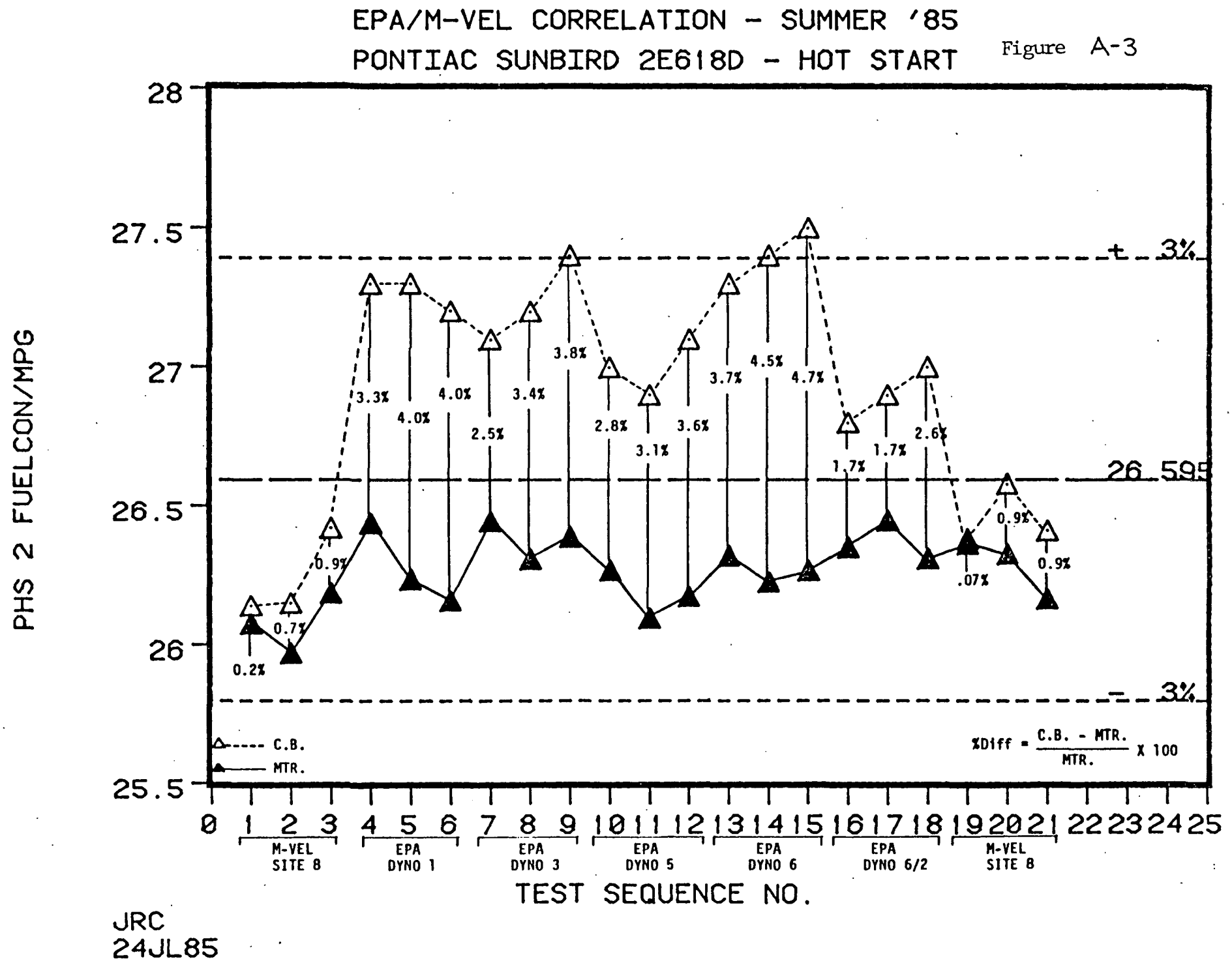
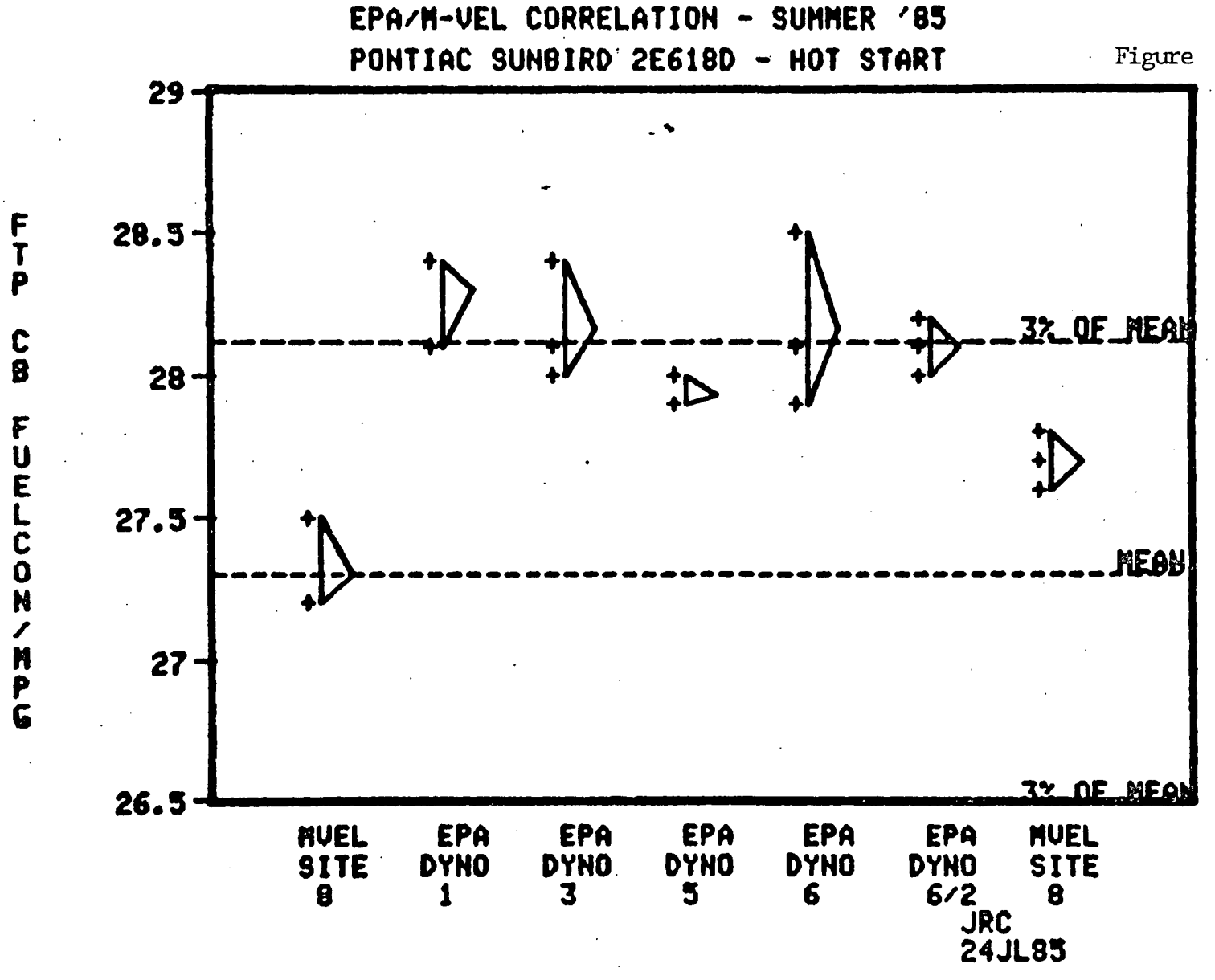
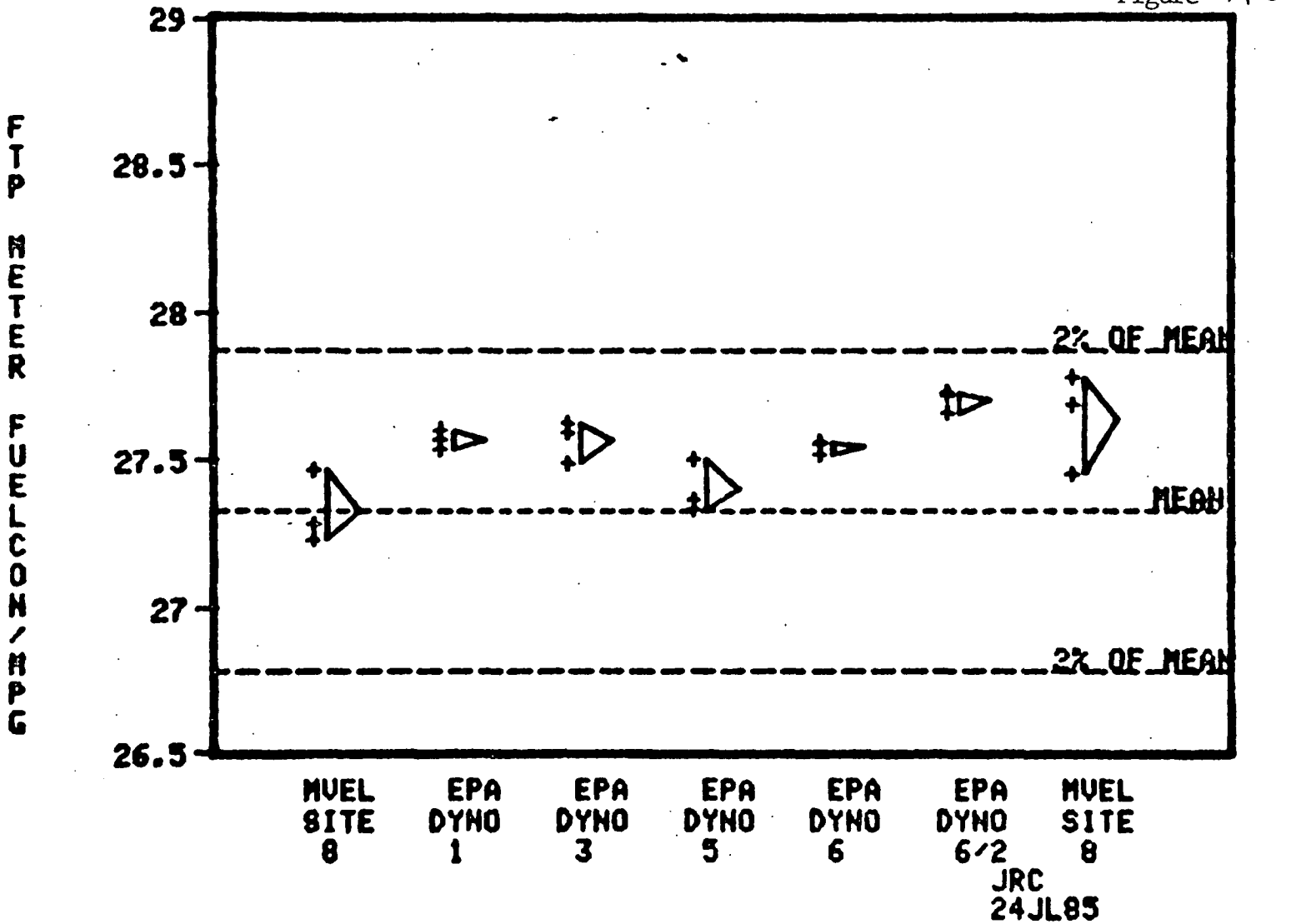

EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START
PHS 2 FUELCON/MPG
28
27.5
27
26.5
26
25.5
+ 3%
26.595
- 3%
0.2%
0.7%
0.9%
3.3%
4.0%
4.0%
2.5%
3.4%
3.8%
2.8%
3.1%
3.6%
3.7%
4.5%
4.7%
1.7%
1.7%
2.6%
.07%
0.9%
0.9%
C.B.
MTR.
%Diff = C.B. - MTR. / MTR. X 100
0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
M-VEL SITE 8
EPA DYNO 1
EPA DYNO 3
EPA DYNO 5
EPA DYNO 6
EPA DYNO 6/2
M-VEL SITE 8
TEST SEQUENCE NO.
JRC
24JL85

Figure A-4


EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START
FTP CB FUELCON/MPG
29
28.5
28
27.5
27
26.5
3% OF MEAN
MEAN
3% OF MEAN
MVEL SITE 8
EPA DYNO 1
EPA DYNO 3
EPA DYNO 5
EPA DYNO 6
EPA DYNO 6/2
MVEL SITE 8
JRC
24JL85

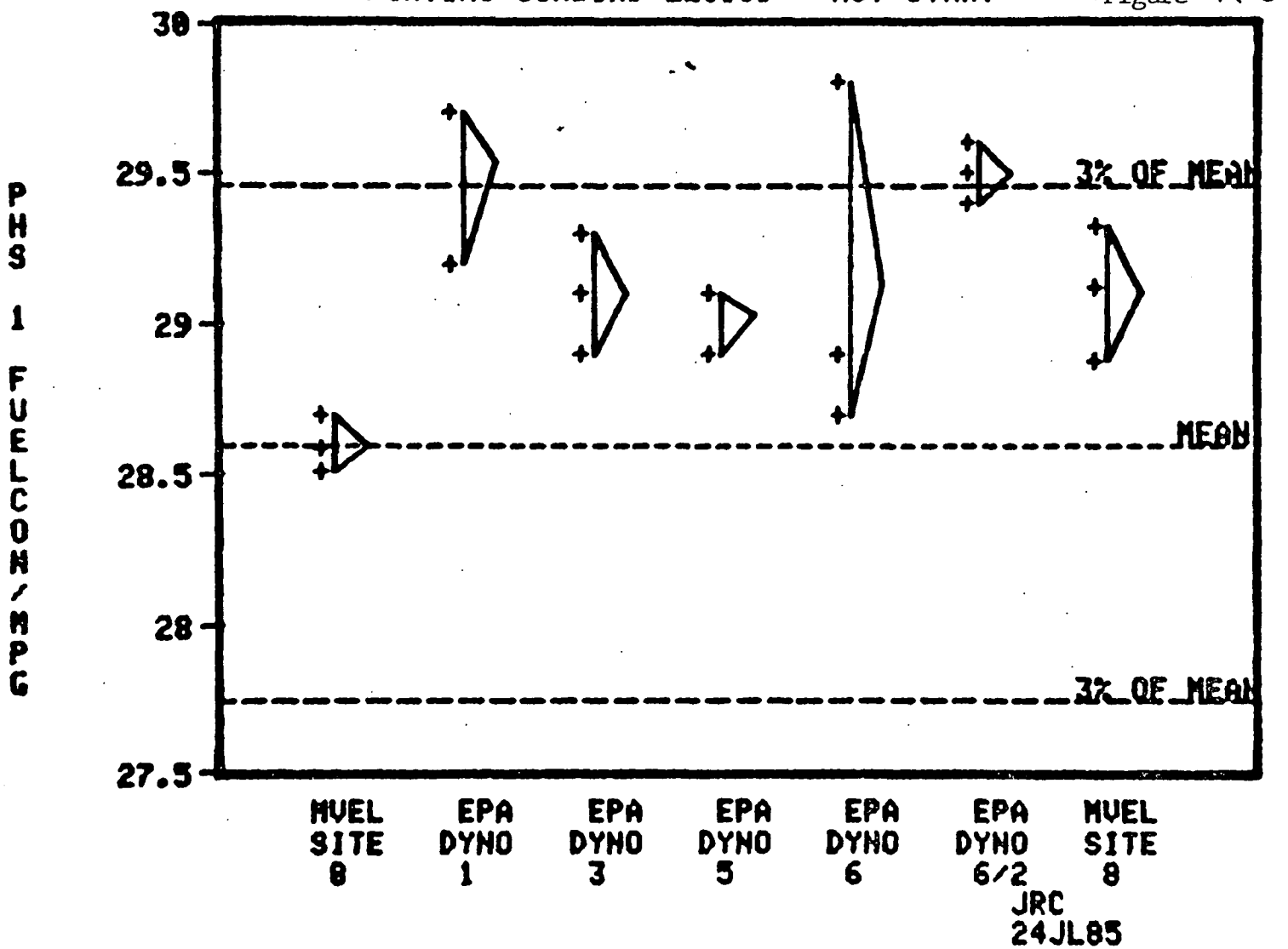
EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START

Figure A-5



EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START

Figure A-6



EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START

Figure A-7

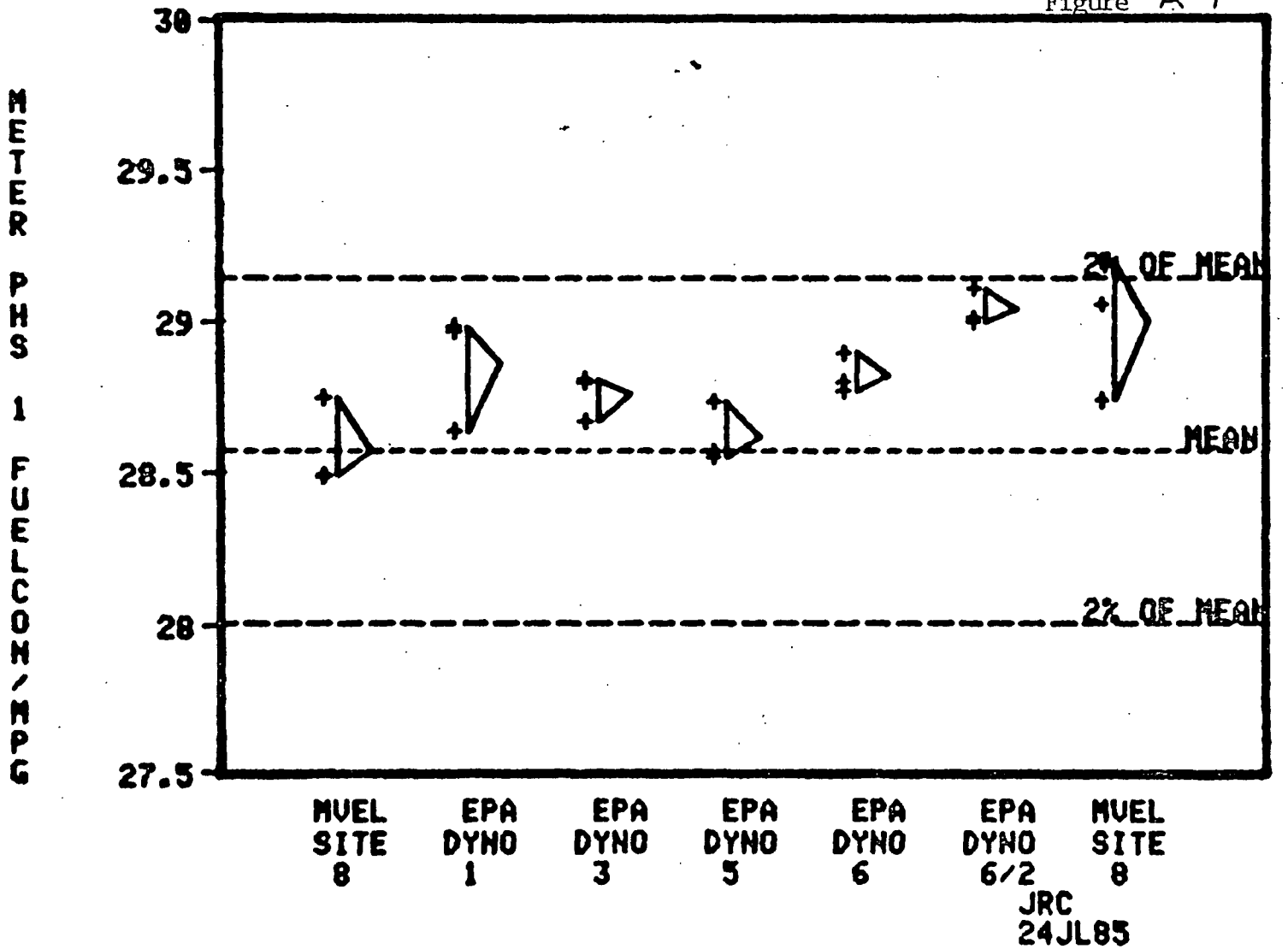


Figure A-8

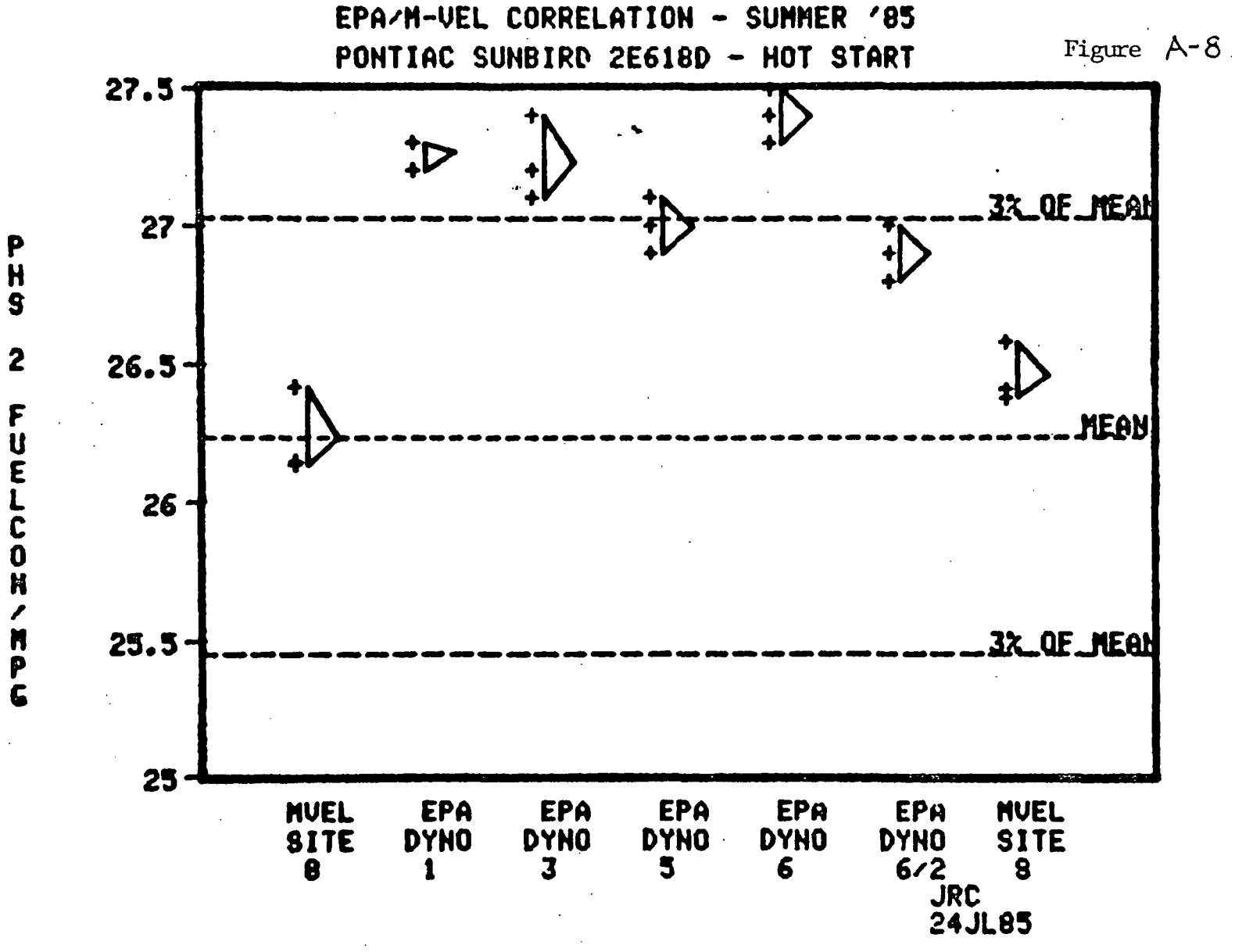
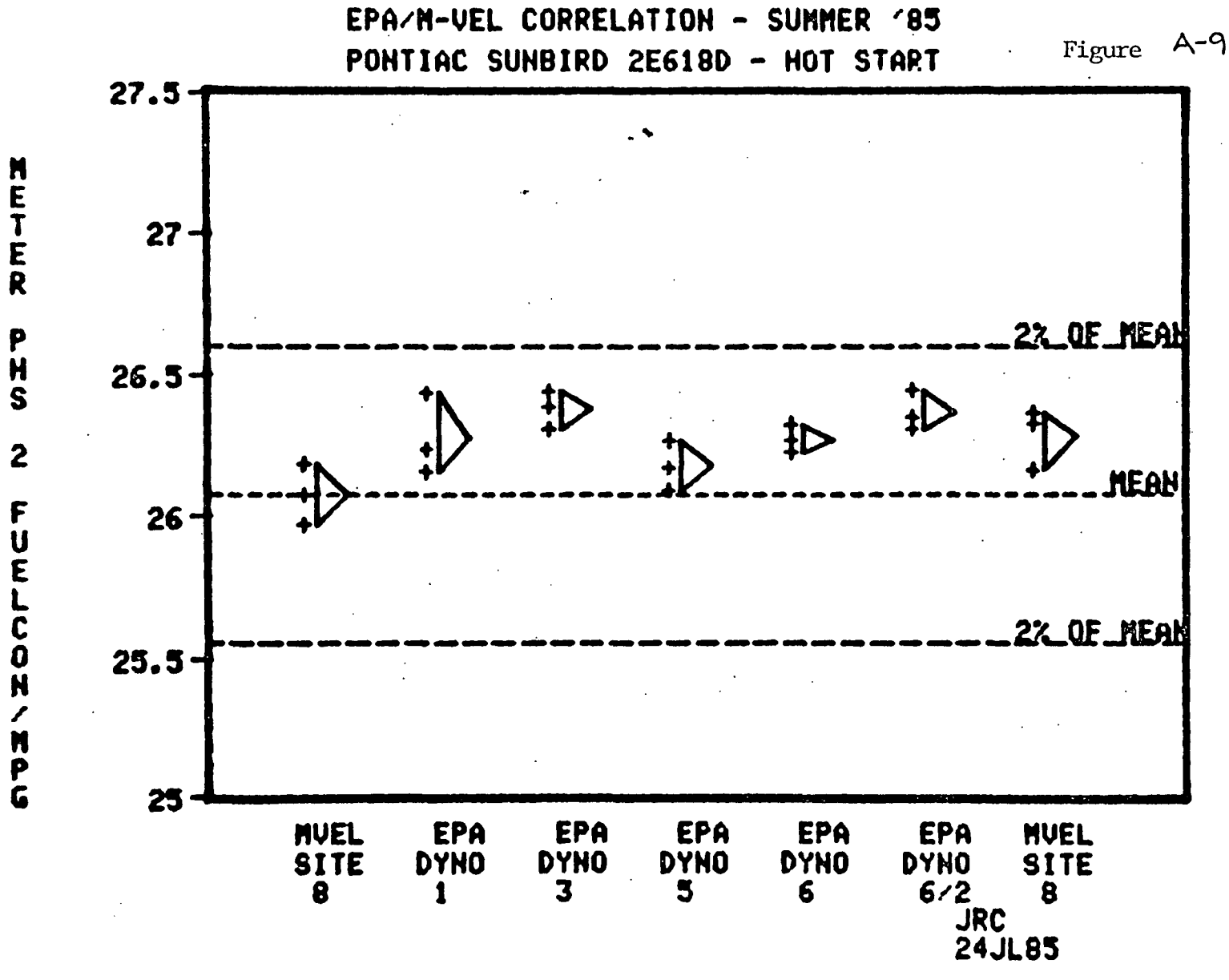
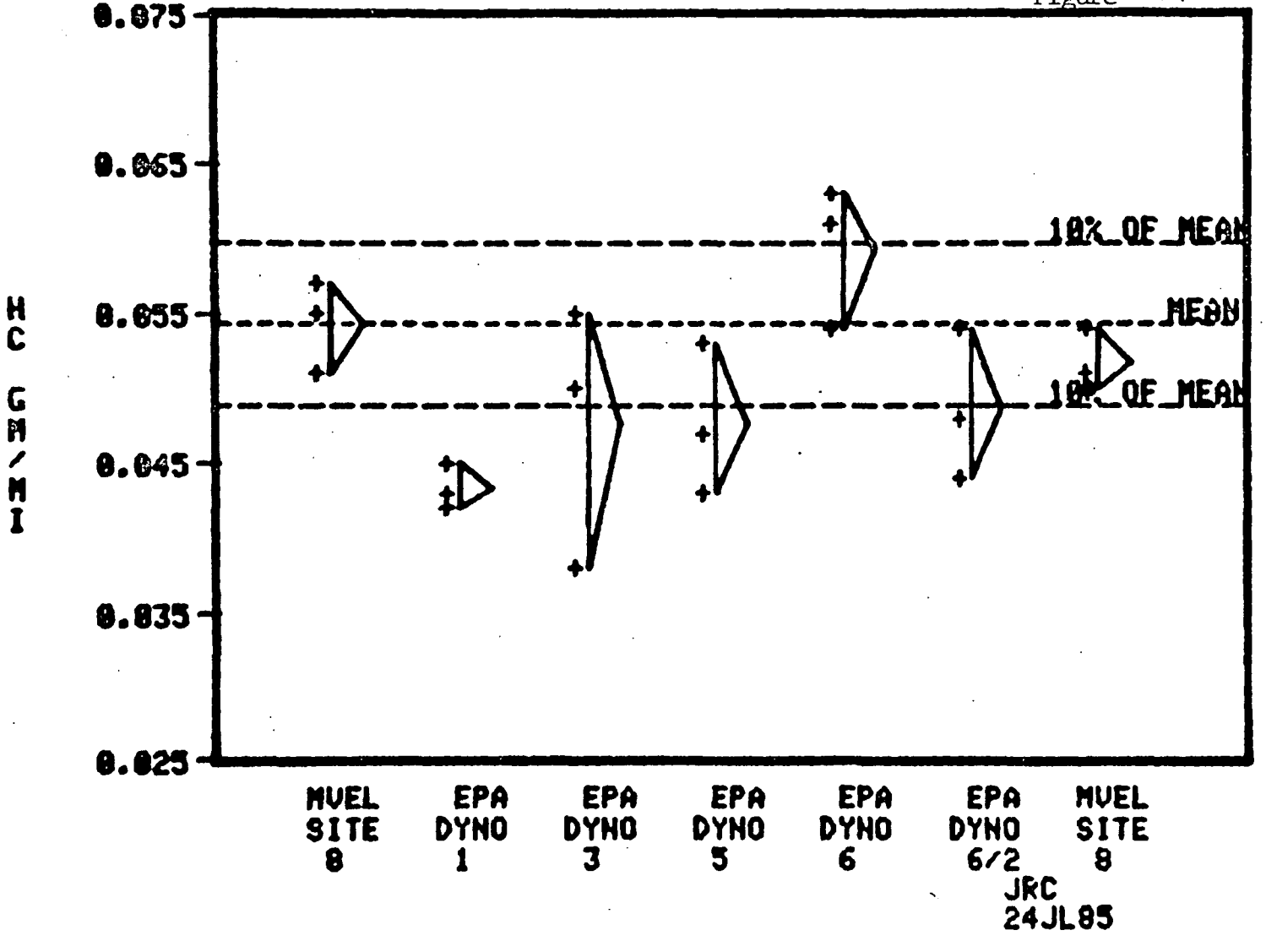

EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START
PHS 2 FUELCON/MPG
27.5
27
26.5
26
25.5
25
3% OF MEAN
MEAN
3% OF MEAN
MVEL SITE 8
EPA DYNO 1
EPA DYNO 3
EPA DYNO 5
EPA DYNO 6
EPA DYNO 6/2
MVEL SITE 8
JRC 24JL85

Figure A-9


EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START
METER PHS 2 FUELCON/MPG
27.5
27
26.5
26
25.5
25
2% OF MEAN
MEAN
2% OF MEAN
MVEL SITE 8
EPA DYNO 1
EPA DYNO 3
EPA DYNO 5
EPA DYNO 6
EPA DYNO 6/2
MVEL SITE 8
JRC
24JL85

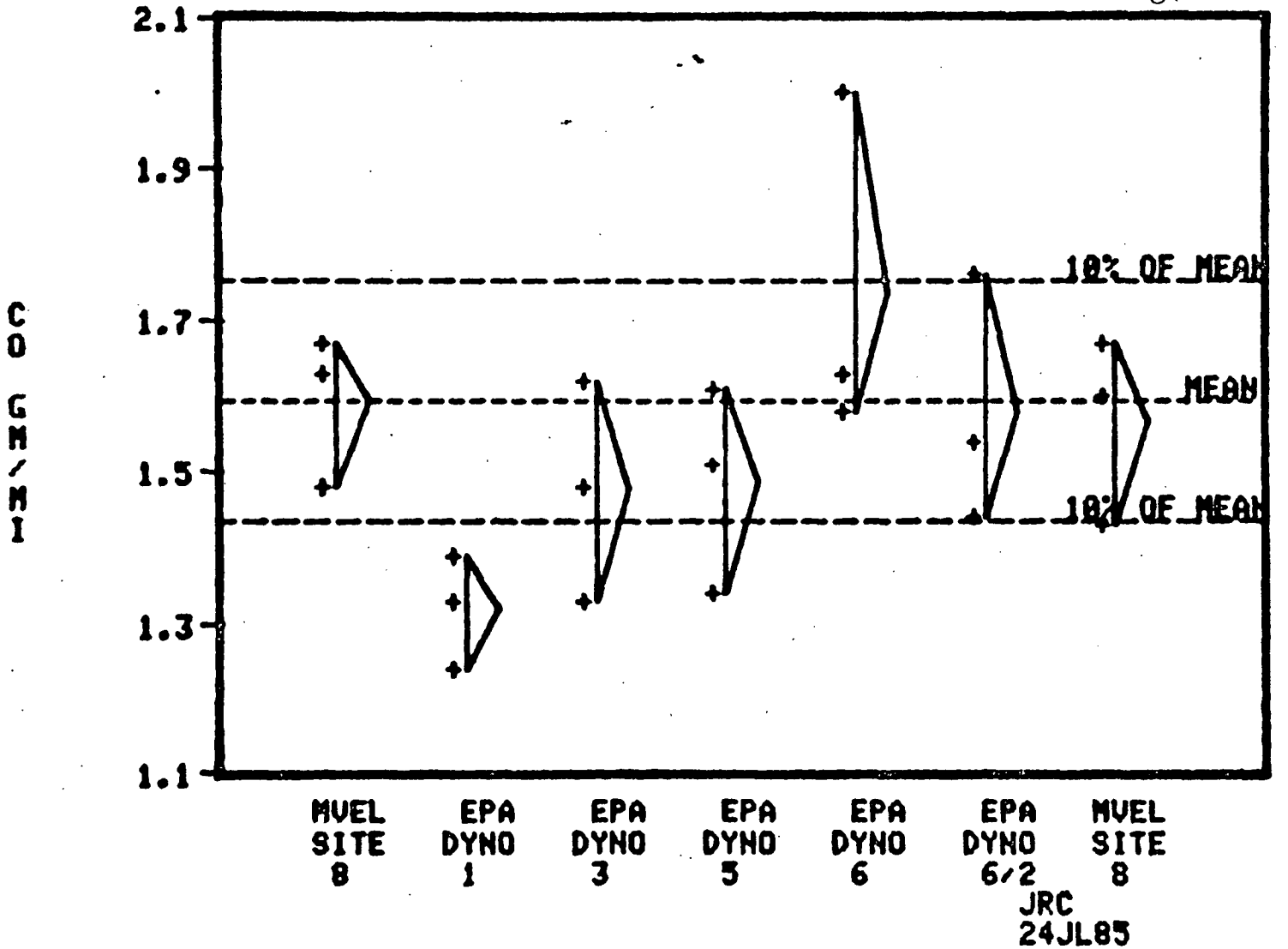
EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START

Figure A-10



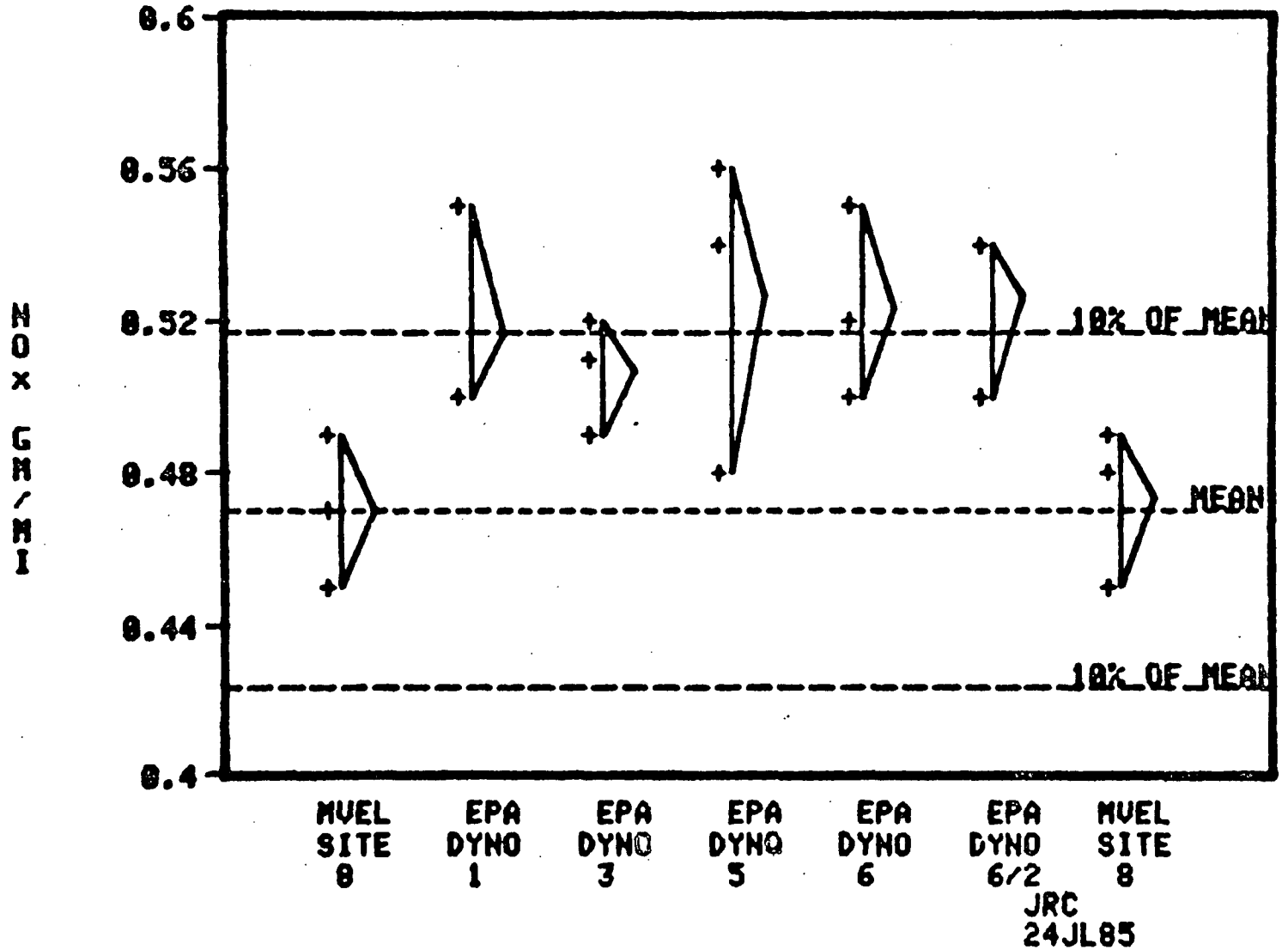
EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START

Figure A-11



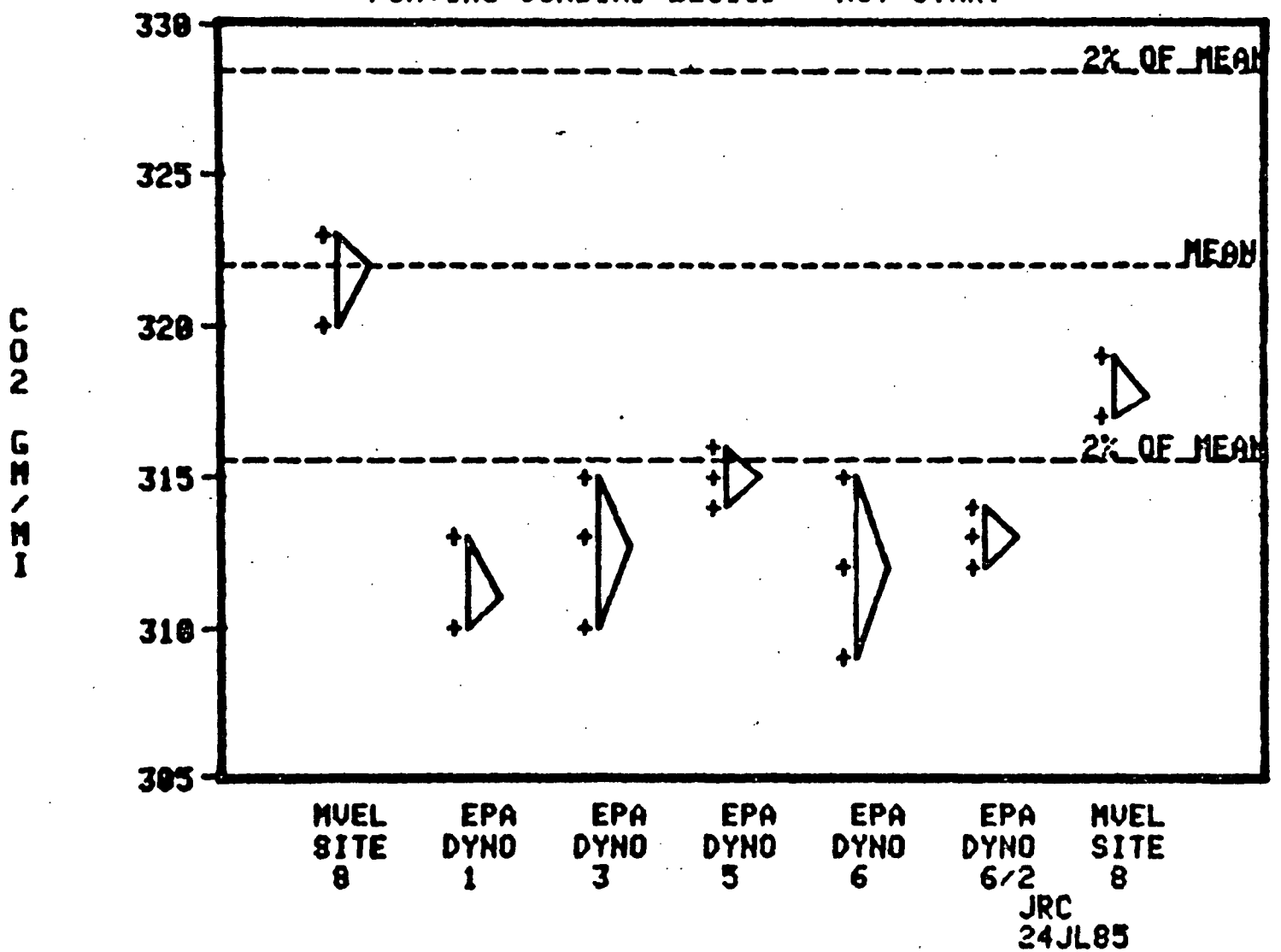
EPA/M-VEL CORRELATION - SUMMER '85

PONTIAC SUNBIRD 2E61SD - HOT START Figure A-12



EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START

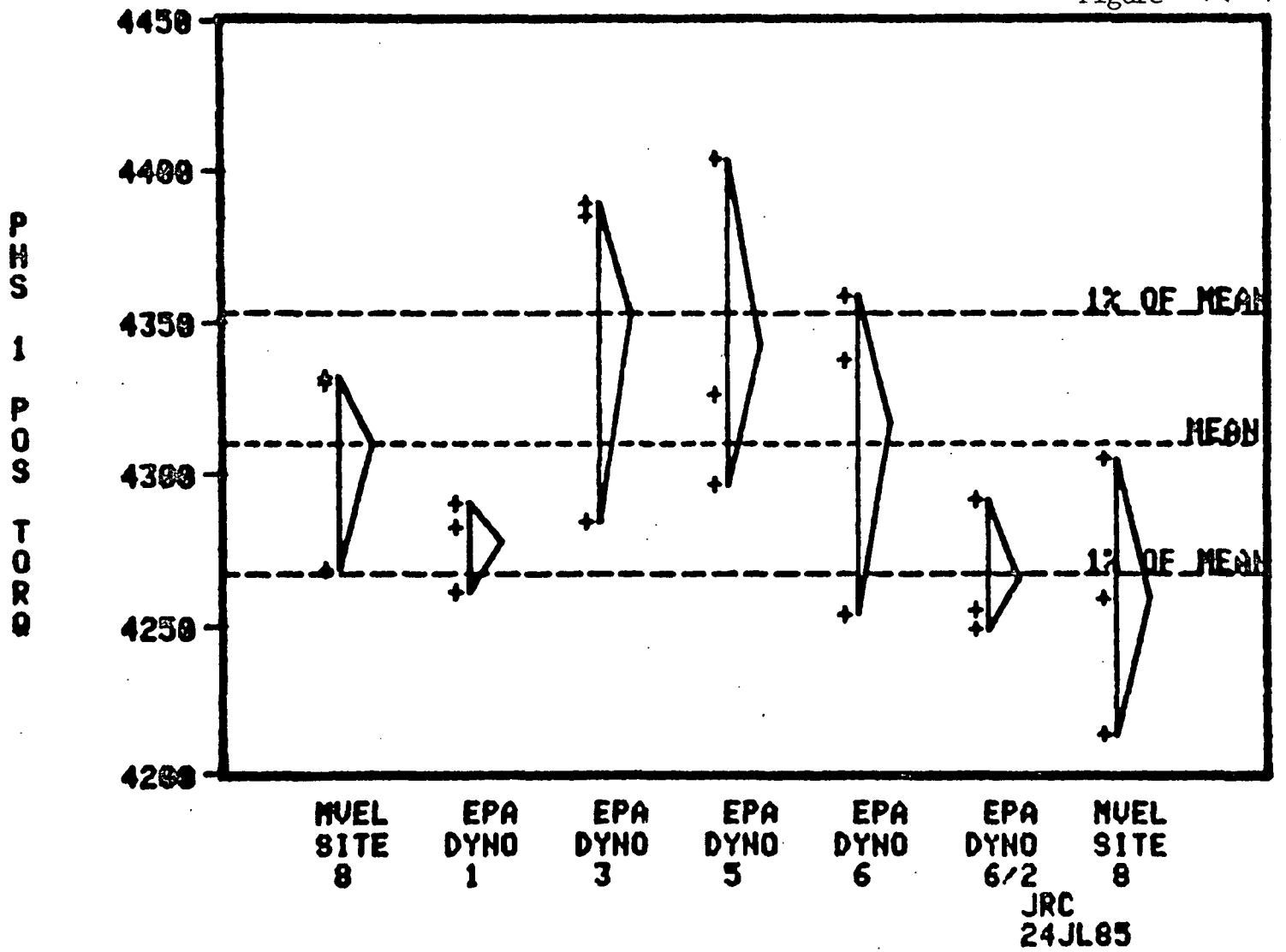
Figure A-13



EPA/M-VEL CORRELATION - SUMMER '85

PONTIAC SUNBIRD 2E618D - HOT START

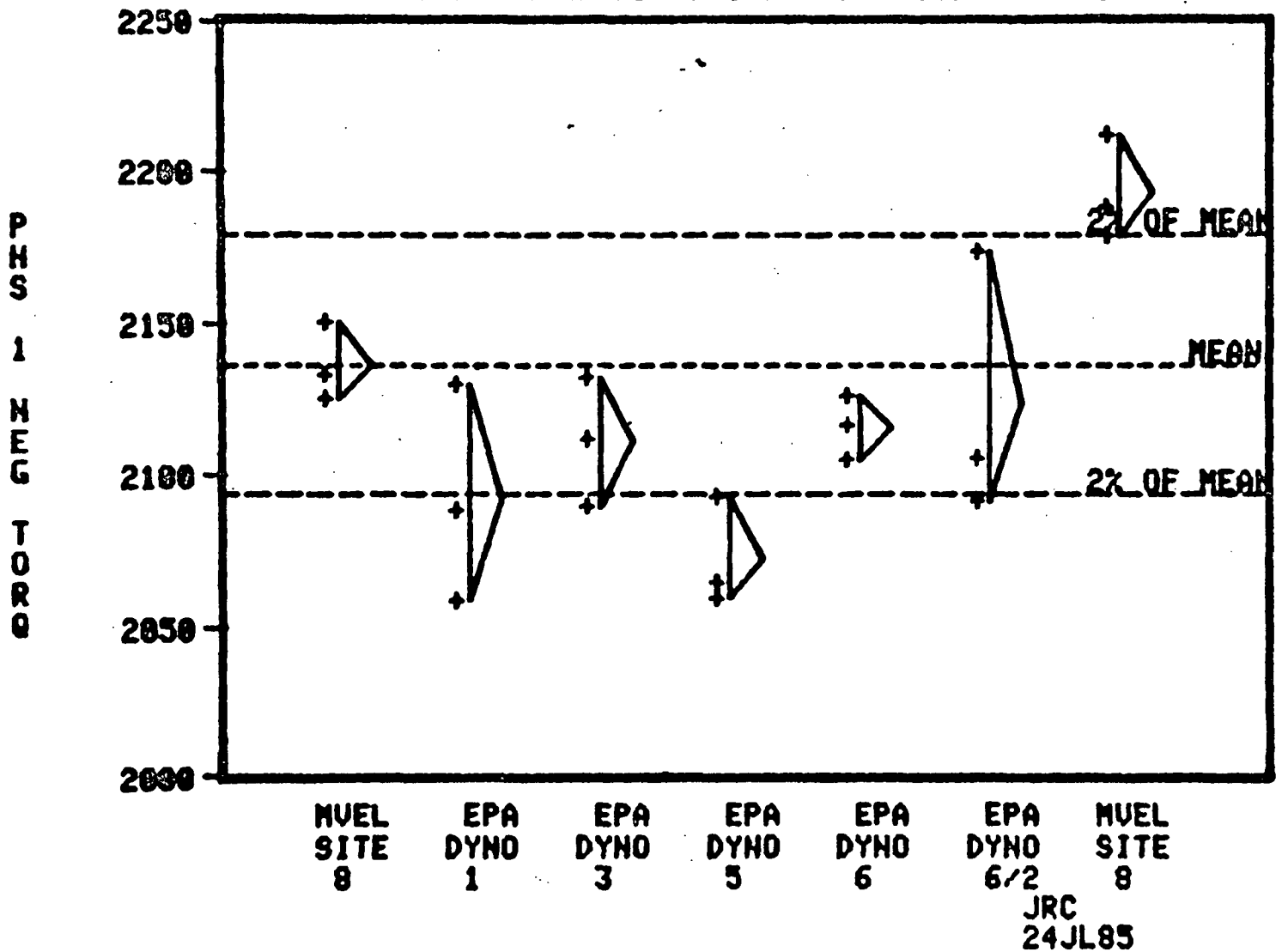
Figure A-14



EPA/M-VEL CORRELATION - SUMMER '85

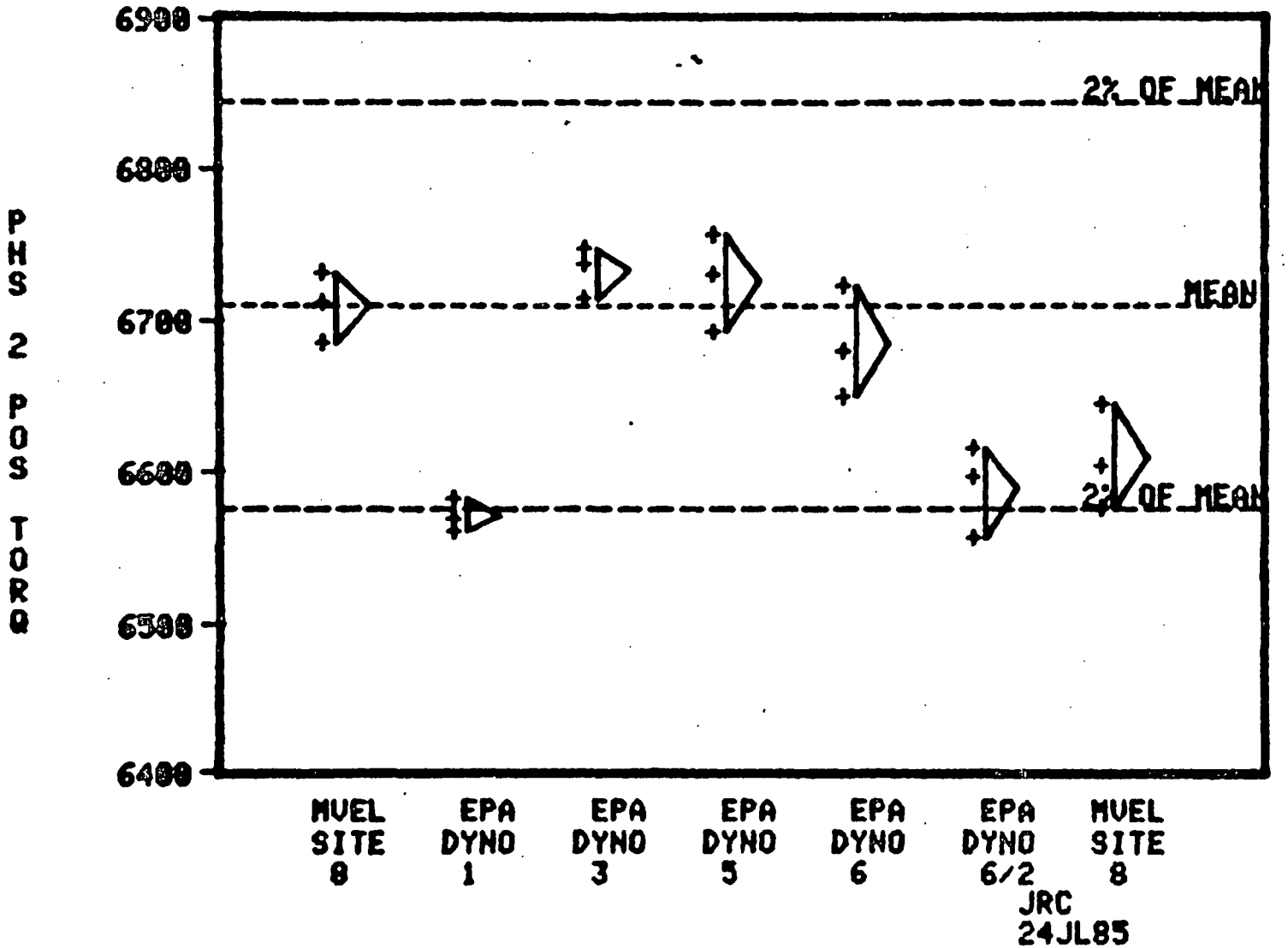
PONTIAC SUNBIRD 2E618D - HOT START

Figure A-15



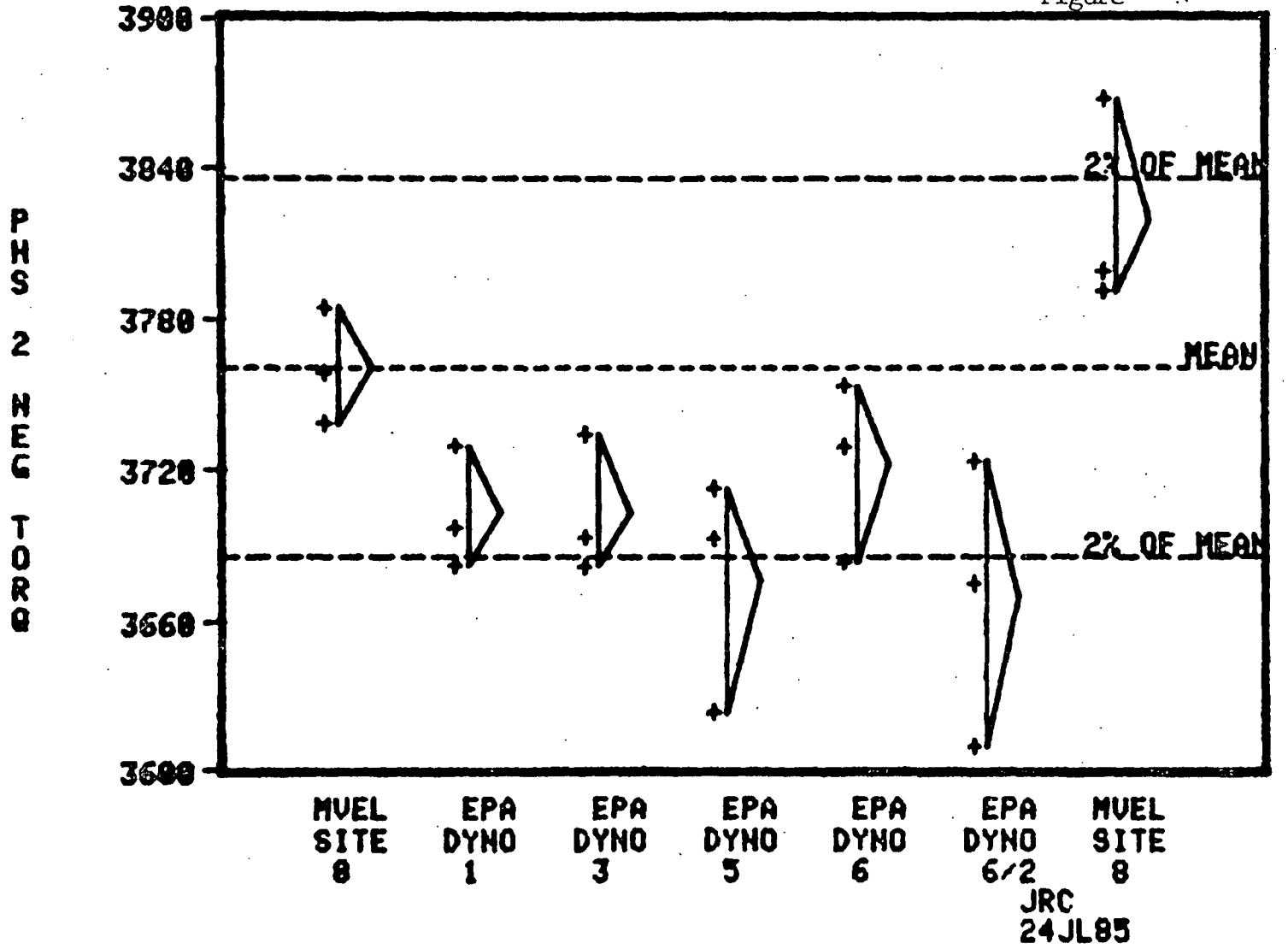
EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E61SD - HOT START

Figure A-16



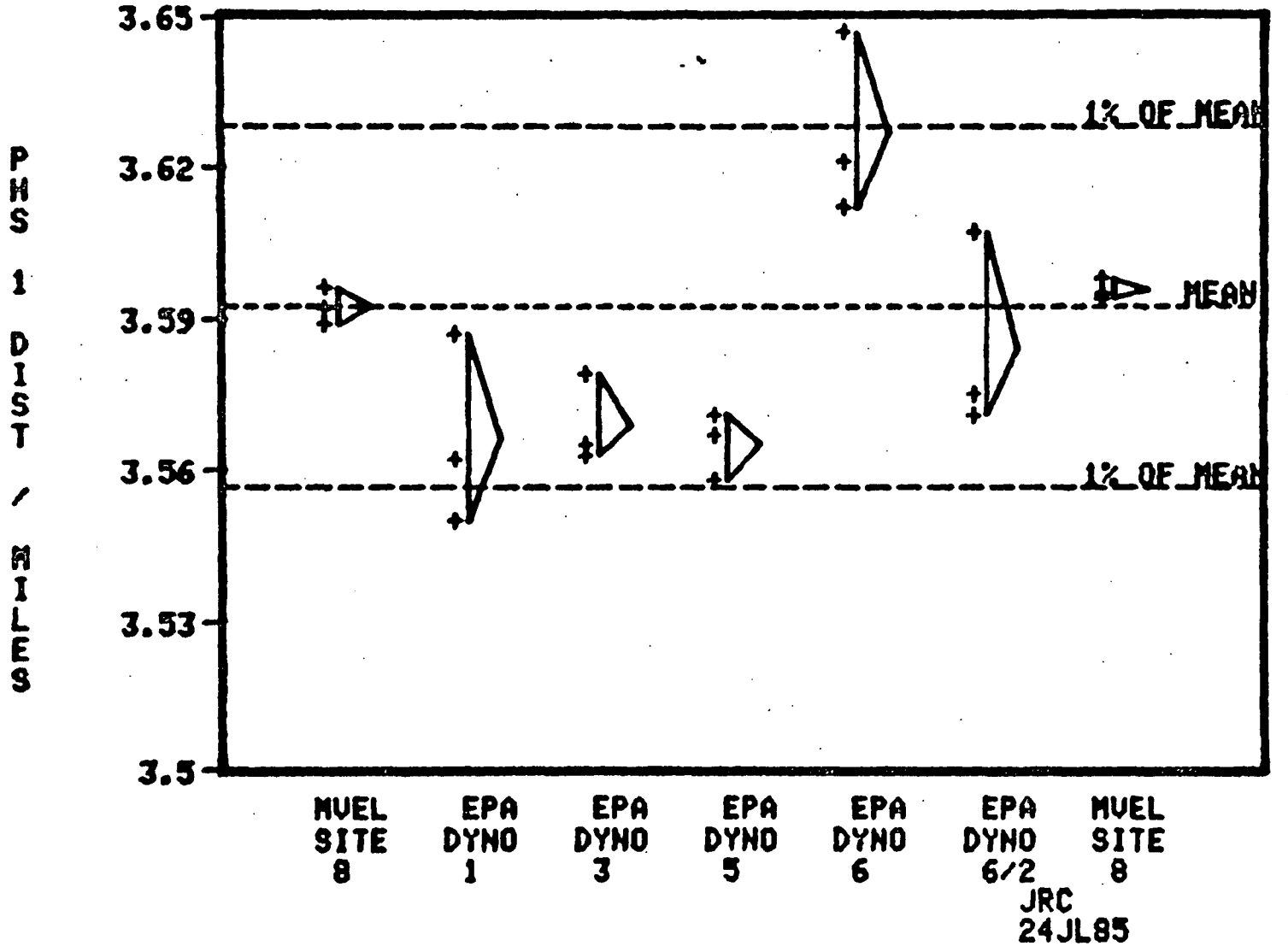
EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START

Figure A-17



EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START

Figure A-18



EPA/M-VEL CORRELATION - SUMMER '85
PONTIAC SUNBIRD 2E618D - HOT START Figure A-19