

Supplement II

Presentation of

Dr. James T. Trainor

J. T. Trainor Testing Co. LLC

BMC/SAE J2430 Dynamometer Test Program

(Standardized Effectiveness Test for

Aftermarket Brake Friction Products)

Presented June 4, 2000, at the

FMSI Annual Meeting

Key Largo, Florida

**1) WHY A STANDARDIZED EFFECTIVENESS TEST
FOR AFTERMARKET BRAKE FRICTION PRODUCTS?**

1. POTENTIAL FOR GOVERNMENT REGULATION

- ** 1992 NHTSA REPORT & LETTER.**
- ** CURRENT EFFORTS BY EUROPEAN FRICTION PRODUCERS
FOR U.S. ADOPTION OF REG. 90 AFTERMARKET STANDARD.**
- ** ACTIVITIES BY OTHER COUNTRIES.**

2. STRINGENT NEW VEHICLE BRAKE REQUIREMENTS

- ** MAJOR OE FRICTION MATERIAL COMPOSITION CHANGES
FOR FMVSS 135 AND CUSTOMER COMFORT REQUIREMENTS.**
- ** REPLACEMENT FRICTION SHOULD BE SUITABLE FOR THESE VEHICLES.**
- ** INCREASED TESTING TO AVOID UNEXPECTED PERFORMANCE.**

**3. INCREASING CUSTOMER INTEREST IN A STANDARDIZED
TEST PROCEDURE FOR RELIABLE & CONSISTENT MATERIAL
COMPARISONS.**

4. ITS THE RIGHT THING TO DO:

- ** LARGE NUMBER OF FRICTION PRODUCERS**
- ** J661 CHASE TEST IS NOT A RELIABLE BASIS FOR ASSESSING
VEHICLE BRAKING PERFORMANCE.**
- ** PUBLIC ASSUMES THERE ARE STANDARDS TO COVER SAFETY
RELATED REPLACEMENT PRODUCTS.**

BMC/SAE J2430 DYNAMOMETER TEST PROGRAM

REVIEW & UPDATE FOR FMSI

JUNE 4, 2000

OCEAN REEF CLUB---KEY LARGO, FL.

OUTLINE OF TOPICS

- I) WHY A STANDARDIZED EFFECTIVENESS TEST
FOR AFTERMARKET BRAKE FRICTION PRODUCTS?**
- II) KEY PROJECT OBJECTIVES**
- III) BACKGROUND--KEY EVENTS (1987-1999)**
- IV) SAE J2430 RECOMMENDED PRACTICE**
- V) J2430 VALIDATION TESTING**
- VI) J2430 APPLICATION TO AFTERMARKET PRODUCTS**
- VII) ACCEPTANCE CRITERIA MEANING?
WHAT THEY DO NOT MEAN?**
- VIII) CURRENT ACTIVITIES AND DIRECTION**
- IX) SUMMARY**

J.T.TRAINOR TESTING CO. LLC
8 RIVENDELL DR.
SHELTON, CT. 06484

IX) SUMMARY-- CONTINUED

4. J2430 APPLICATION TO AFTERMARKET PRODUCTS

- ** FIXED TEST CONDITIONS--EACH APPLICATION**
- ** ACCEPTANCE CRITERIA & SUMMARY GRAPHS**
- ** EFFECTIVENESS & FADE TEST ONLY**

5. WHAT DOES MEETING CRITERIA MEAN/NOT MEAN:

- ** GUIDELINES FOR QUANTITATIVE & CONSISTENT MATERIAL ASSESSMENT**

**** CAN'T MAKE CONCLUSION ON INDIVIDUAL VEHICLE MEETING FMVSS.**

- ** J2430 INTENDED TO BE PART OF TESTING PROTOCOL.**
- ** BMC/FMC POSITION PAPER**

6. CURRENT ACTIVITIES

- ** EXPAND INDUSTRY UNDERSTANDING & USE.**
- ** MECHANISM TO MAINTAIN ENGINEERING INTEGRITY**
- ** ANALYTICAL APPROACHES TO GENERALIZE**

THANK YOU

IX) SUMMARY

- 1. WHY AN AFTERMARKET EFFECTIVENESS STANDARD**
 - ** NO U.S. GOVERNMENT STANDARD FOR AFTERMARKET**
 - ** GOVERNMENTS MOVING TOWARD REGULATION**
 - ** FUNDAMENTAL CHANGES IN FRICTION COMPOSITIONS**
 - ** CUSTOMERS WANT COMPARABLE PERFORMANCE DATA.**
 - ** CONSUMERS ASSUME STANDARDS.**
 - ** PREFER VOLUNTARY STANDARD.**
- 2. SAE J2430 RECOMMENDED PRACTICE**
 - ** SEVERAL TYPES OF USE.**
 - ** PARALLELS FMVSS 135**
 - ** RANGE OF DISC & DRUM BRAKE APPLICATIONS**
 - ** DETAILED FOR REPRODUCIBILITY & VALIDATION.**
 - ** NO PASS/FAIL ACCEPTANCE CRITERIA**
- 3. VALIDATION TESTING**
 - ** MATERIAL DIFFERENTIATION**
 - ** TEST/TEST & LAB/LAB**
 - ** DYNO/VEHICLE CORRELATION**

VII) CURRENT STATUS & ACTIVITIES

- 1. COMPANIES RUNNING J2430 TESTS ON AFTERMARKET PRODUCTS.**
 - ** ASSESS MATERIALS & CONFIRM LAB/LAB REPRODUCIBILITY**
- 2. COMMUNICATIONS TO BROADEN INDUSTRY UNDERSTANDING & USE.**
- 3. ESTABLISH A MECHANISM TO MAINTAIN ENGINEERING INTEGRITY.**
 - ** IMPROVE THE J2430 PROCEDURE & REPORTING FORMAT**
 - ** INTRODUCE ADDITIONAL VEHICLE APPLICATIONS.**

BMC FRICTION MATERIAL COMMITTEE POSITION PAPER

**THE BMC/FMC POSITION PAPER WILL BE FOUND ON THE BMC
WEB SITE (www.brakecouncil.org).**

**** ENDORSE J2430**

**** DESCRIBE ACCEPTANCE CRITERIA & INTERPRETATION.**

WHAT DOES MEETING ACCEPTANCE CRITERIA NOT MEAN?

- 1. SINCE ACCEPTANCE CRITERIA ARE BASED ON FIXED VEHICLE BRAKE SYSTEM PARAMETERS, THAT MAY DIFFER FOR AN INDIVIDUAL VEHICLE, MEETING THESE CRITERIA IS NOT A RELIABLE BASIS FOR CONCLUDING THAT AN INDIVIDUAL VEHICLE WILL OR WILL NOT MEET THE APPLICABLE FMVSS.**
- 2. ACCEPTANCE CRITERIA ARE MINIMUM VALUES & DO NOT DISTINGUISH AMONG MATERIALS THAT MEET THESE LEVELS:
** MEETING THE CRITERIA DOES NOT SPECIFY THE BEST EFFECTIVENESS FOR A GIVEN BRAKE APPLICATION.**
- 3. J2430 IS NOT DESIGNED TO ASSESS OTHER IMPORTANT ASPECTS OF MATERIAL PERFORMANCE SUCH AS, NOISE, DURABILITY, DRUM/ROTOR COMPATIBILITY OR EXTENDED LIGHT DUTY SERVICE.**

***DECISION TO COMMERCIALIZE A FRICTION PRODUCT
SHOULD BE BASED ON A PROTOCOL OF TEST METHODS.
J2430 IS INTENDED TO BE PART OF THIS PROTOCOL.***

VII) WHAT DOES MEETING ACCEPTANCE CRITERIA MEAN?

1. FMVSS'S ESTABLISH MINIMUM VEHICLE BRAKE PERFORMANCE:

- ** SEVERE DUTY CONDITIONS.**
- ** DO NOT ADDRESS DURABILITY, NOISE OR TYPICAL SERVICE BRAKING CONDITIONS.**

2. MATERIAL EFFECTIVENESS IS A MAJOR, BUT NOT THE ONLY FACTOR DETERMINING VEHICLE BRAKE PERFORMANCE:

- ** FRICTION PRODUCER DOES NOT KNOW CONDITIONS OF INDIVIDUAL VEHICLES USING A FRICTION MATERIAL.**
- ** CAN'T RELIABLY PREDICT VEHICLE BRAKING PERFORMANCE OF AN INDIVIDUAL VEHICLE FROM MATERIAL EFFECTIVENESS ALONE.**

3. ACCEPTANCE CRITERIA ARRIVED AT BY DEFINING CERTAIN VEHICLE BRAKE SYSTEM PARAMETERS. WITH THESE PARAMETERS FIXED, FMVSS STOPPING DISTANCE & BALANCE CAN BE EXPRESSED IN TERMS OF MATERIAL EFFECTIVENESS AND MEASURED FROM J2430 DATA.

5. ACCEPTANCE CRITERIA PROVIDE A QUANTITATIVE ASSESSMENT OF MATERIAL EFFECTIVENESS THAT IS TIED DIRECTLY TO FMVSS REQUIREMENTS.

- ** INTENT IS THAT ACCEPTANCE CRITERIA SERVE AS USEFUL & REALISTIC GUIDELINES TO PROVIDE A CONSISTENT, QUANTITATIVE BASIS FOR ASSESSING MATERIAL EFFECTIVENESS.**

BMC OBJECTIVE

THE BMC FRICTION MATERIAL COMMITTEE OBJECTIVE STATES IN PART:

THE BMC FRICTION MATERIALS COMMITTEE RESOLVES THAT AFTERMARKET BRAKE FRICTION MATERIALS SHOULD NOT DETERIORATE VEHICLE BRAKE PERFORMANCE BELOW THE APPLICABLE FEDERAL MOTOR VEHICLE SAFETY STANDARD, AND RECOGNIZES THAT ON-VEHICLE, DYNAMOMETER, OR OTHER EQUIVALENT TESTING OR ENGINEERING OR COMPUTER ANALYSES MAY BE EMPLOYED BY MANUFACTURERS OF REPLACEMENT FRICTION IN MAKING GOOD FAITH EFFORTS TO DETERMINE FMVSS PERFORMANCE.

THE BMC FRICTION MATERIALS COMMITTEE RECOMMENDS:

- i) AFTERMARKET FRICTION PERFORMANCE SHOULD BE TIED TO THE APPLICABLE FMVSS.**
- ii) BRAKE PERFORMANCE OF AN INDIVIDUAL VEHICLE IS INFLUENCED BY FACTORS IN ADDITION TO THE FRICTION MATERIAL BEING TESTED. FOR THIS REASON, THE FRICTION PRODUCER MAKES CERTAIN ASSUMPTIONS TO DEFINE VEHICLE SPECIFIC BRAKE PARAMETERS. BASED ON THESE PARAMETERS, FMVSS STOPPING DISTANCE AND BALANCE REQUIREMENTS CAN BE EXPRESSED IN TERMS OF MATERIAL EFFECTIVENESS.**

II) KEY PROJECT OBJECTIVES

- 1. SINGLE END DYNAMOMETER TEST**
- 2. PARALLEL FMVSS 135**
 - ** BECOMING U.S. GOVERNMENT BRAKE PERFORMANCE STANDARD FOR HYDRAULIC BRAKE VEHICLES.**
- 3. REPRODUCIBILITY**
 - ** LAB/LAB, AS WELL AS TEST/TEST**
 - ** FUNDAMENTAL CHANGE FROM A/B/C COMPARISON TESTS**
- 4. CAPABILITY TO DIFFERENTIATE AMONG MATERIALS.**
- 5. APPLICABLE TO A RANGE OF VEHICLE BRAKES.**
 - ** INITIALLY, VEHICLE SPECIFIC APPLICATIONS**
 - ** WANT AN ANALYTICAL BASIS FOR BROADER ASSESSMENT OF MATERIAL ACCEPTABILITY.**
- 5. ACCEPTANCE CRITERIA**
 - ** SEPARATE DOCUMENTS FOR SAE RECOMMENDED PRACTICE & FOR APPLICATION TO AFTERMARKET PRODUCTS**
- 6. PUBLISHED AS SAE RECOMMENDED PRACTICE**
- 7. REASONABLE TEST TIME**

III) KEY EVENTS 1987--1995

1987

**** SAE FORMS PASSENGER CAR BRAKE EFFECTIVENESS TASK FORCE**

1992

**** NHTSA LETTER TO AFTERMARKET COMPANIES & REPORT ON
AFTERMARKET DISC & DRUM LINING PERFORMANCE.**

1993

**** BMC FRICTION COMMITTEE INITIATES SUPPORT FOR SAE TASK FORCE
** THREE PHASE PROGRAM:
i) SINGLE APPLICATION DISC TEST
ii) SINGLE APPLICATION DRUM LINING TEST
iii) GENERALIZED PROCEDURE WITH ACCEPTANCE CRITERIA**

1994

**** DYNO & VEHICLE TESTING FOR J1652**

1995

**** SAE PUBLISHES J1652--SINGLE APPLICATION DISC BRAKE TEST
** BMC/FMC FUNDING FOR REAR DRUM BRAKE PROCEDURE**

III) KEY EVENTS 1996--1999

1996

- ** SAE TASK FORCE REJECTS CONCEPT TO EXTRAPOLATE LINING PERFORMANCE ACROSS PLATFORMS**
- ** BMC/FMC PUBLISHES OBJECTIVE--RELATES FRICTION MATERIAL PERFORMANCE TO FMVSS, NOT TO OE MATERIAL**
- ** COMPLETE PROCEDURE & TESTING OF DRUM LINING PROCEDURE.
--DECISION NOT TO PURSUE SAE STANDARD**
- ** BMC/FMC SUPPORT SAE TASK FORCE FOR GENERALIZED PROCEDURE**

1997

- ** FMVSS/EFFECTIVENESS MODEL**
- ** DRAFT GENERALIZED DISC & DRUM LINING PROCEDURE--J2430**
- ** BMC/FMC FUNDING FOR J2430 VALIDATION TESTING**

1998

- ** INSTRUMENTED VEHICLE TESTING--5 VEHICLES**
- ** ESTIMATE BRAKE INERTIA FROM FRONT/REAR BRAKE TORQUE RATIO**

1999

- ** SAE PUBLISHED J2430 RECOMMENDED PRACTICE**
- ** COMPANIES RUNNING J2430 TESTS**
- ** PRELIMINARY WORK ON ANALYTICAL APPROACH TO APPLY J2430 TO A BROADER RANGE OF VEHICLE BRAKES.**

J2430 PROCEDURE SYNOPSIS

	NUMBER OF APPLICATIONS	SPEED km/h	SUSTAINED DECEL m/s^2	SUSTAINED PRESSURE kPa	INITIAL TEMP. DRUM/ROTOR DEG.C
I. CHECK	5	50-3	3	-	<100
	5	100-3	3	-	100
	3	50-3	-	~75 N	100
	5	50	RAMP	-	100
	5	100	RAMP	-	100

INSTRUMENT CHECK COOLING CURVE

BURNISH	200	80-3	3	-	-
EFFECTIVENESS	5	50	RAMP	-	100
	5	100	RAMP	-	100
	6	100-3	6.4	-	100
FADE	15	120-56	3	-	55 FIRST SNUB

HOT PERFORMANCE 2 100-3 1) BEST COLD EFFECT.
2) @ 500N.

COOLING	4	50-3	3	-	-
RECOVERY RAMP	2	100	RAMP	-	-

REBURNISH	35	80-3	3	-	100 FIRST STOP
EFFECTIVENESS	5	50	RAMP	-	100
	5	100	RAMP	-	100
	5	160	RAMP	-	100

POST TEST COOLING CURVES

IV) SAE J2430 RECOMMENDED PRACTICE

1. J2430 USEFUL FOR:

- ** QA TESTING**
- ** FORMULATION DEVELOPMENT**
- ** BRAKE HARDWARE DESIGN/EVALUATION**
- ** AFTERMARKET MATERIAL CHARACTERIZATION**

2. APPROVED & PUBLISHED BY SAE-AUGUST 1999

3. PARALLELS FMVSS 135, NOT FMVSS 105

- ** FMVSS 135 DYNAMOMETER SIMULATION TEST.**

4. SUITABLE FOR A RANGE OF DISC & DRUM BRAKE APPLICATIONS

- ** OUTLINES DATA REQUIRED TO RUN A SPECIFIC APPLICATION.**

5. DETAILED SPECIFICATION-REQUIRED FOR REPRODUCIBILITY

- ** ONLY ONE WAY TO RUN EACH APPLICATION, NO OPTIONS.**

7. NO PASS/FAIL ACCEPTANCE CRITERIA

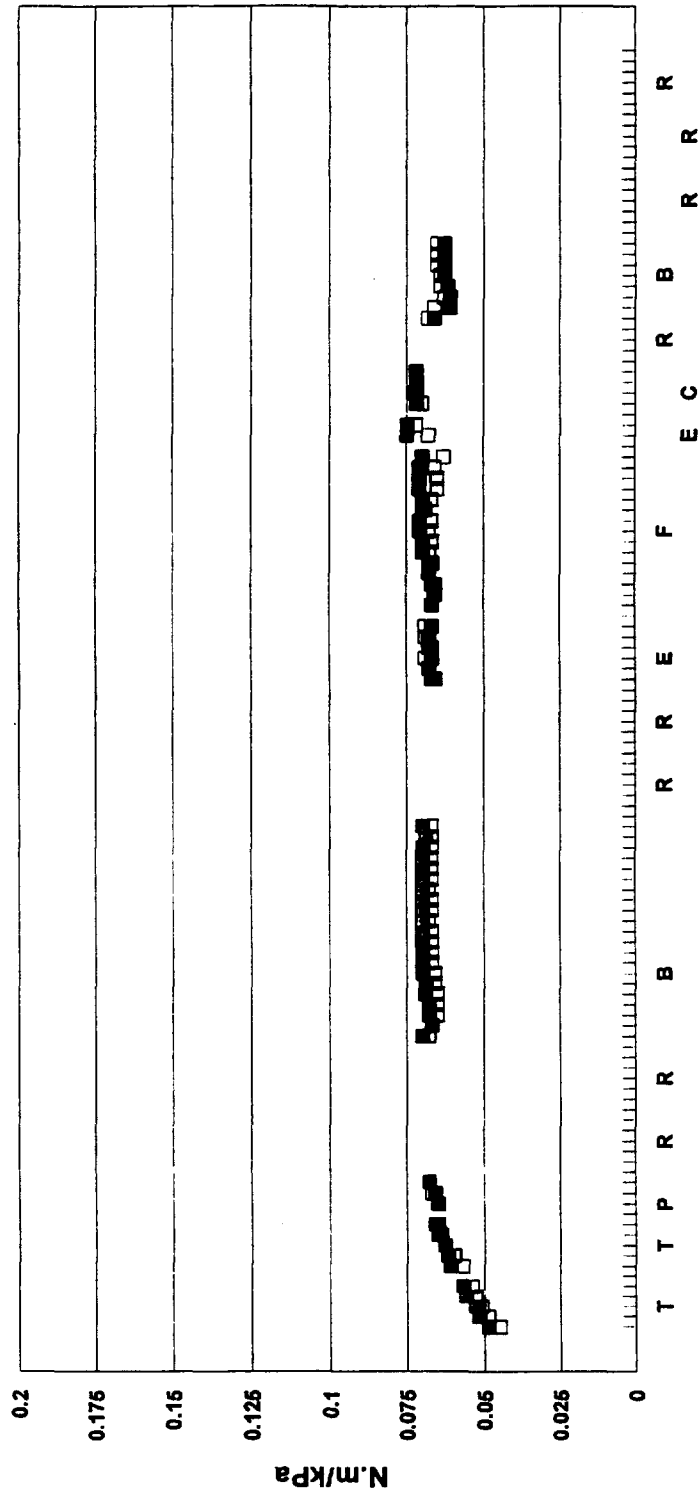
- ** NO MEANING TO SAY A MATERIAL PASSES J2430**

8. DESIGNED FOR EFFECTIVENESS & FADE EVALUATION

- ** NOT INTENDED TO ASSESS WEAR, NOISE, ROTOR WEAR
OR EXTENDED LIGHT DUTY VEHICLE SERVICE.**

FIGURE 4

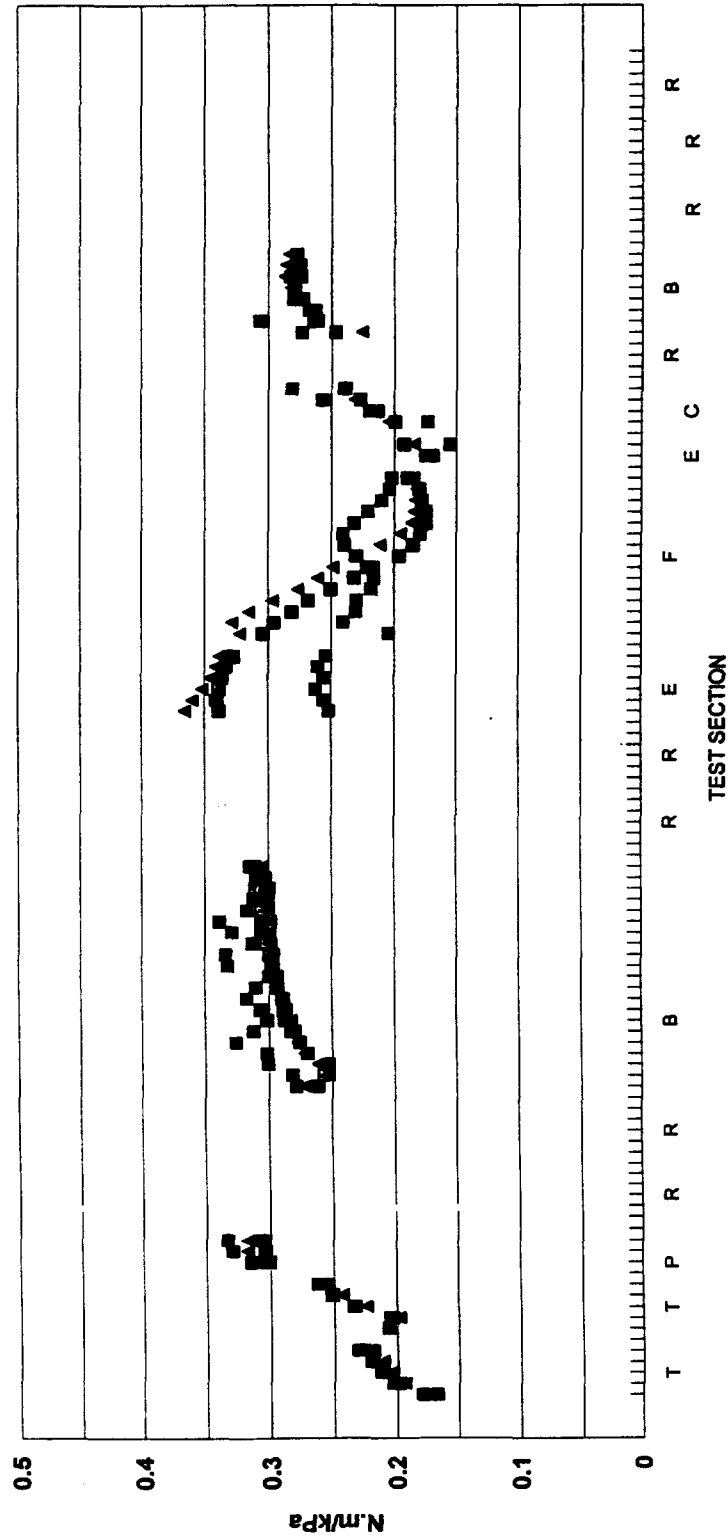
CARAVAN REAR DRUM LINING
J2430 AVERAGE SPECIFIC TORQUE



■ LNK 98A423-A □ LNK 98A423-B

FIGURE 5

**FORD EXPLORER FRONT BRAKE
J2430 AVERAGE SPECIFIC TORQUE**



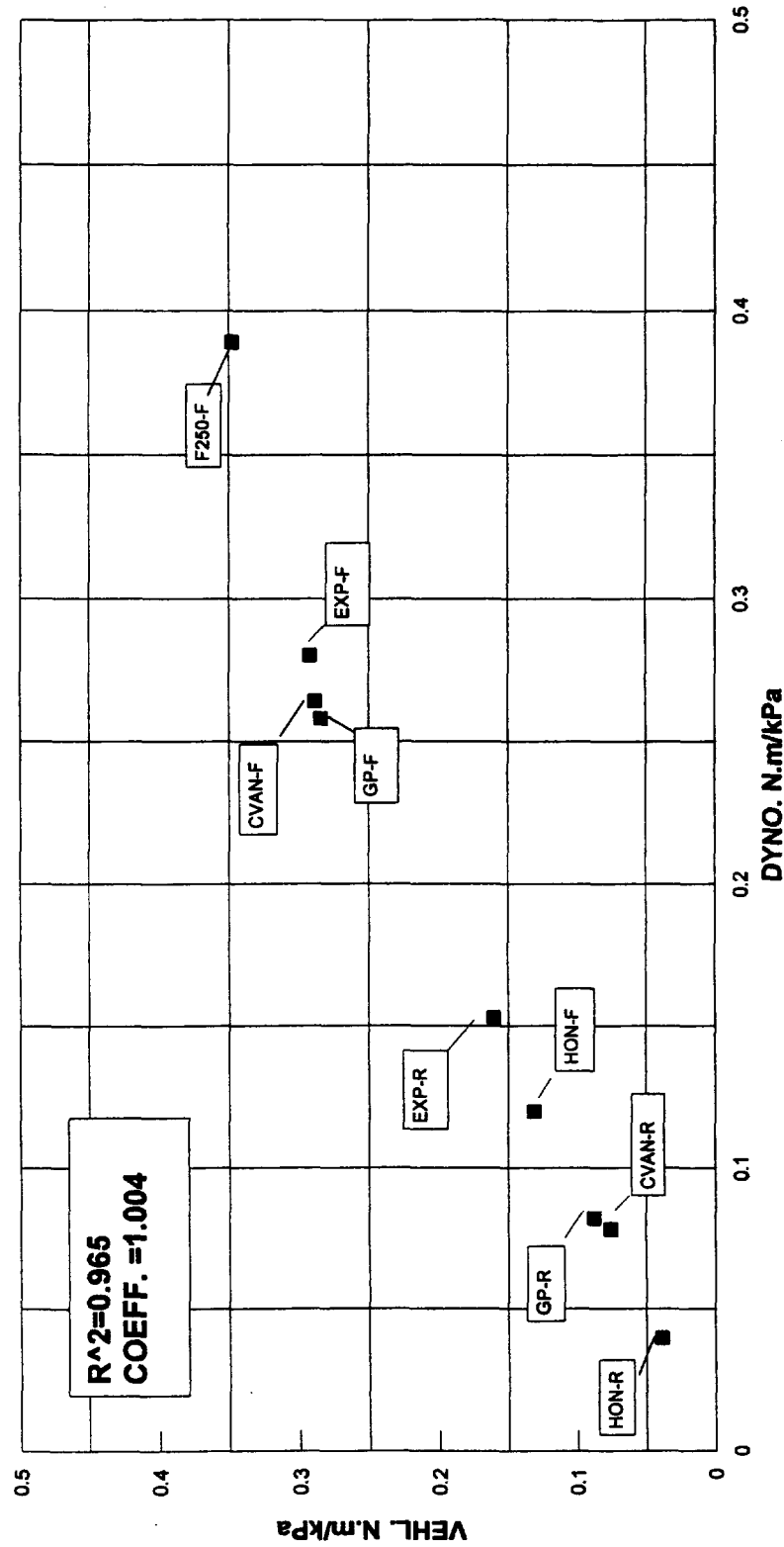
■ LNK 98A266-E ▲ LNK 98A266-D ■ GTL M06017-7

LNK AVG. 0.263
GTL 0.261

FIGURE 6

J2430 DYNO/VEHICLE CORRELATION

REGRESSED SPECIFIC TORQUE-RAMP APPLICATIONS



TOTAL TEST FOR SECTIONS ANALYZED

VI) J2430 APPLICATION TO AFTERMARKET FRICTION PRODUCTS

1. SPECIAL CONSIDERATIONS

I) EXACTLY SAME TEST CONDITIONS AT ALL LABS FOR A GIVEN BRAKE.

- ** BRAKE HARDWARE SPECIFICATIONS**
- ** NEW OE ROTOR/DRUM EACH TEST**
- ** WHEEL LOAD**
- ** BRAKE COOLING CURVES**
- ** DYNAMOMETER SETUP CONTROL SHEET--EACH APPLICATION**
- ** EXCEL PROGRAM TO VALIDATE EACH TEST PROCEDURE**
- ** TEST LABS. HAVE HARDWARE & TEST CONDITIONS FOR THE 9 APPLICATIONS RELEASED TO DATE**

2. SPECIFIC ACCEPTANCE CRITERIA--BASED ON FMVSS 135

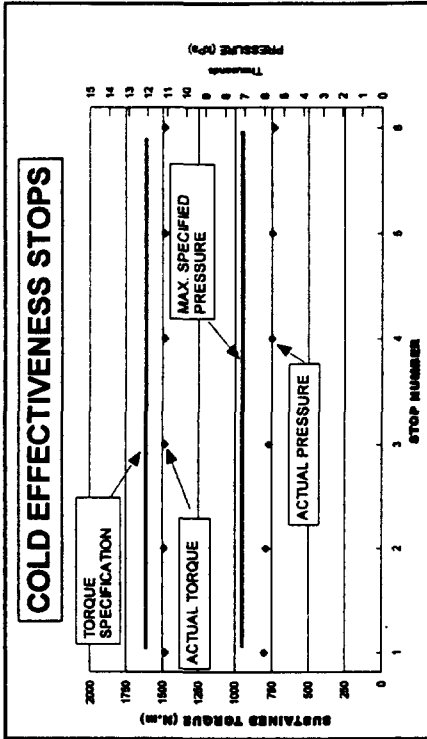
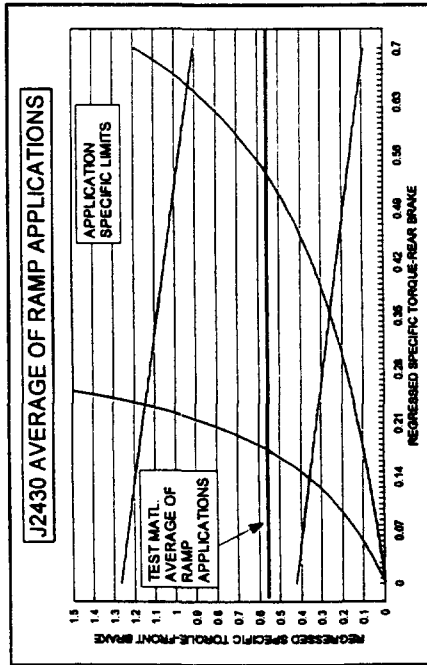
- ** BCM/FMC RECOMMENDS MEET ALL CRITERIA**
- ** SUMMARY GRAPHS**
 - i) RAMP APPLICATIONS MEET FMVSS/EFFECTIVENESS SPACE**
 - ii) COLD EFFECTIVENESS STOPS**
 - iii) HOT EFFECTIVENESS STOPS**
 - iv) FADE SNUBS**
 - v) POST TEST STRUCTURAL INTEGRITY**

J2430 DYNO TEST SETUP PARAMETERS

1998 FORD EXPLORER 4 DOOR

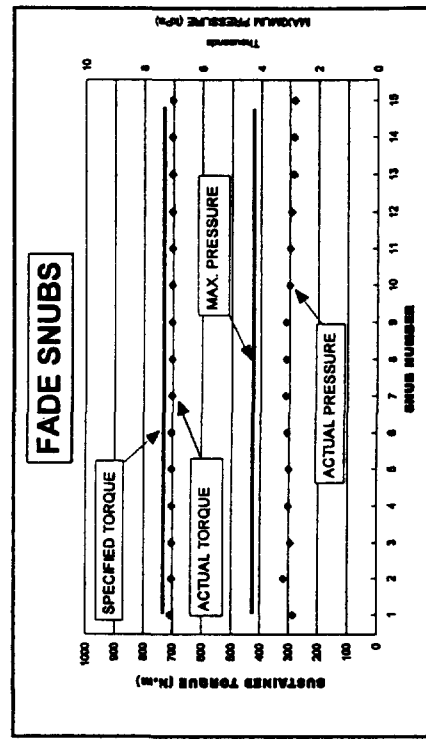
REQUIRED TEST PARAMETER	UNITS	VEHICLE	FRONT BRAKE	REAR BRAKE
1. OE BRAKE PART NUMBERS:				
1.1 FRONT BRAKE ROTOR			F67Z1125BA	F57A-20026-A
1.2 REAR DISC ROTOR				
1.3 REAR DRUM				
1.4 OE FRICTION			ABEX 6083EE	ABEX 6083EE
2. ROLLING RADIUS	m	0.357		
3. WHEEL LOAD (CALCULATED FROM SPECIFIED INERTIA)	Kg		855	353
4. EFFECTIVE BRAKE INERTIA (FROM INERTIA ADJUSTMENT)	Kg*m ²	308	109	45
5. PRESSURE APPLY RATE BEFORE KNEE	kPa/s		6290	6290
6. PROP VALVE ACTIVATION PRESSURE	kPa			
7. POST KNEE PRESSURE APPLY RATE	kPa/s			
8. SUSTAINED TORQUE CORRESPONDING TO:				
8.1 0.15g	N.m		449	185
8.2 0.31g	N.m		928	383
8.3 0.65g	N.m		1945	803
8.4 0.76g	N.m		2276	939
8.5 0.80g	N.m		2394	988
8.6 1.00g	N.m		2892	1235
9. SUSTAINED PRESSURE CORRESPONDING TO:				
9.1 75 N PEDAL FORCE	kPa		3350	3295
9.2 500 N WITH POWER	kPa		9214	9387
9.3 500 N NO POWER	kPa		2576	2605
9.4 687 N WITH POWER	kPa		10231	10399
9.5 687N NO POWER	kPa		3687	3736
9.6 116.5 N POWER	kPa		5432	5464
OTHER DATA FOR EFFECTIVENESS CALCULATIONS:				
10. CENTER OF GRAVITY				
10.1 @ LLW	mm	714		
10.2 @GW	mm	701		
11. WHEEL BASE	mm	2832		
12. FULLY LOADED STATIC WEIGHTS				
12.1 TOTAL VEHICLE	Kg	2426		
12.2 FRONT AXLE	Kg	1160		
13. LIGHTLY LOADED STATIC WEIGHTS				
13.1 TOTAL VEHICLE	Kg	2130		
13.2 FRONT AXLE	Kg	1144		

SUMMARY ANALYSIS--AFTERMARKET FRICTION MATERIAL CHARACTERIZATION SAMPLE BASED ON SAE J2430



HOT EFFECTIVENESS STOPS

	REQUIRED	ACTUAL
STOP #1		
SUSTAINED PRESSURE (kPa)		
SUSTAINED TORQUE (N.m)		
STOP #2		
SUSTAINED PRESSURE (kPa)		
SUSTAINED TORQUE (N.m)		



POST TEST STRUCTURAL INTEGRITY

TEST DOCUMENTATION

FRICTION MATERIAL: _____

FRICTION MANUFACTURER: _____

BRAKE APPLICATION: _____

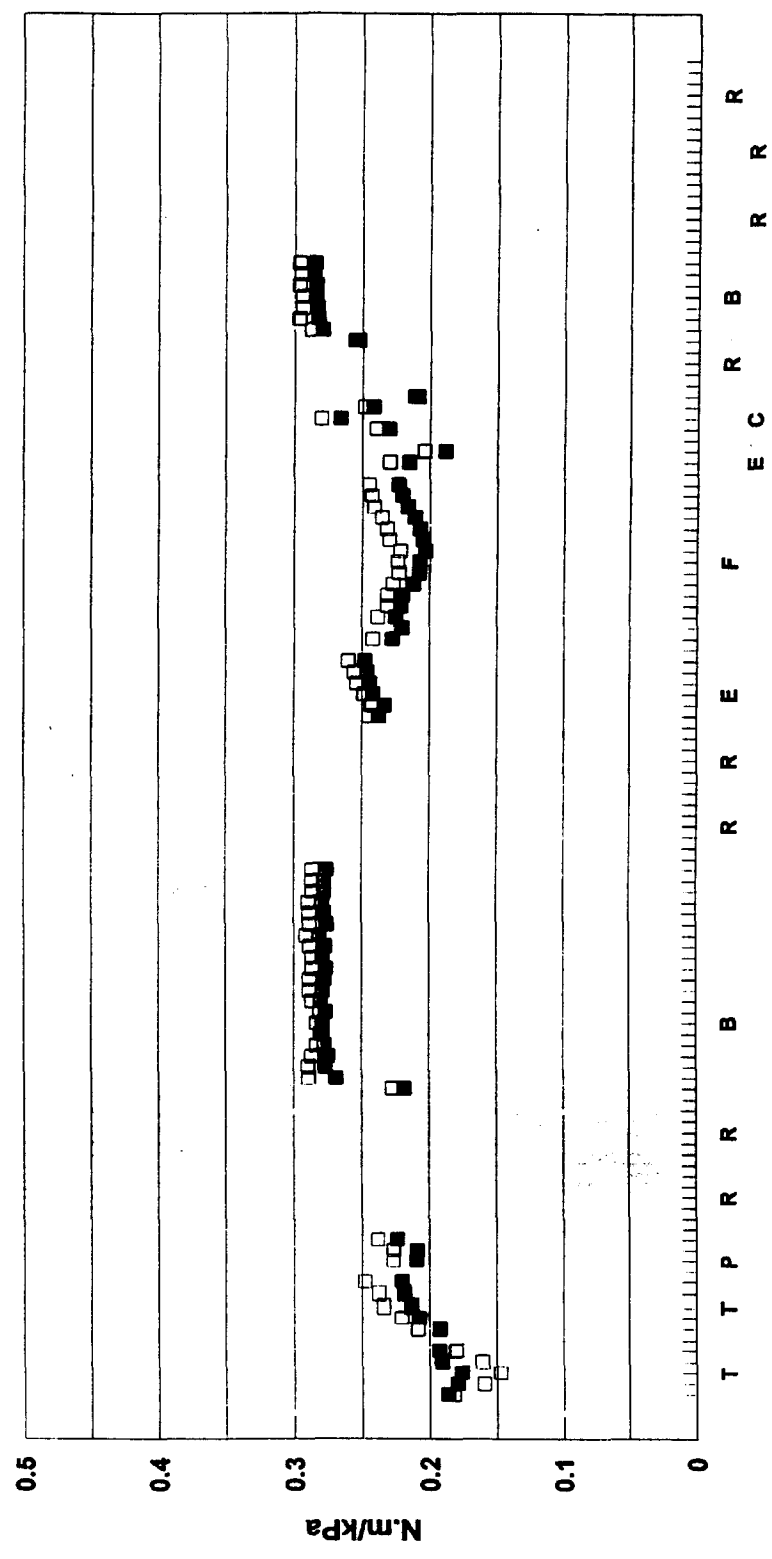
TEST LABORATORY: _____

TEST NUMBER/DATE RUN: _____ / _____

COMMENTS

FIGURE 3

GRAND PRIX FRONT BRAKE
J2430 AVERAGE SPECIFIC TORQUE

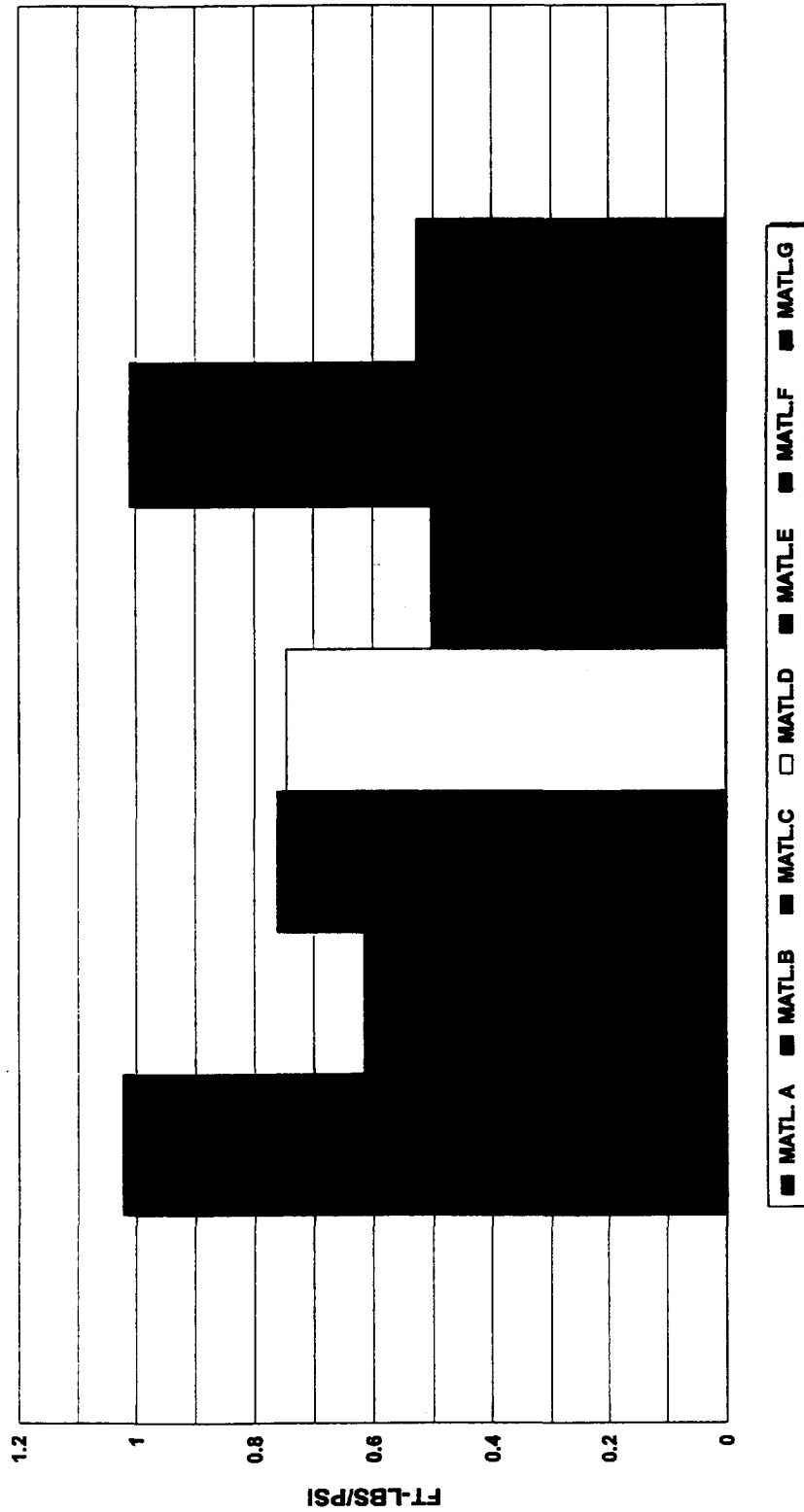


■ GTL M06024-06 □ GTL M06024-07

FIGURE 2

J1653 COMPARISON OF COMMERCIAL DRUM LININGS

FMSI-242 CHEVY CAPRICE

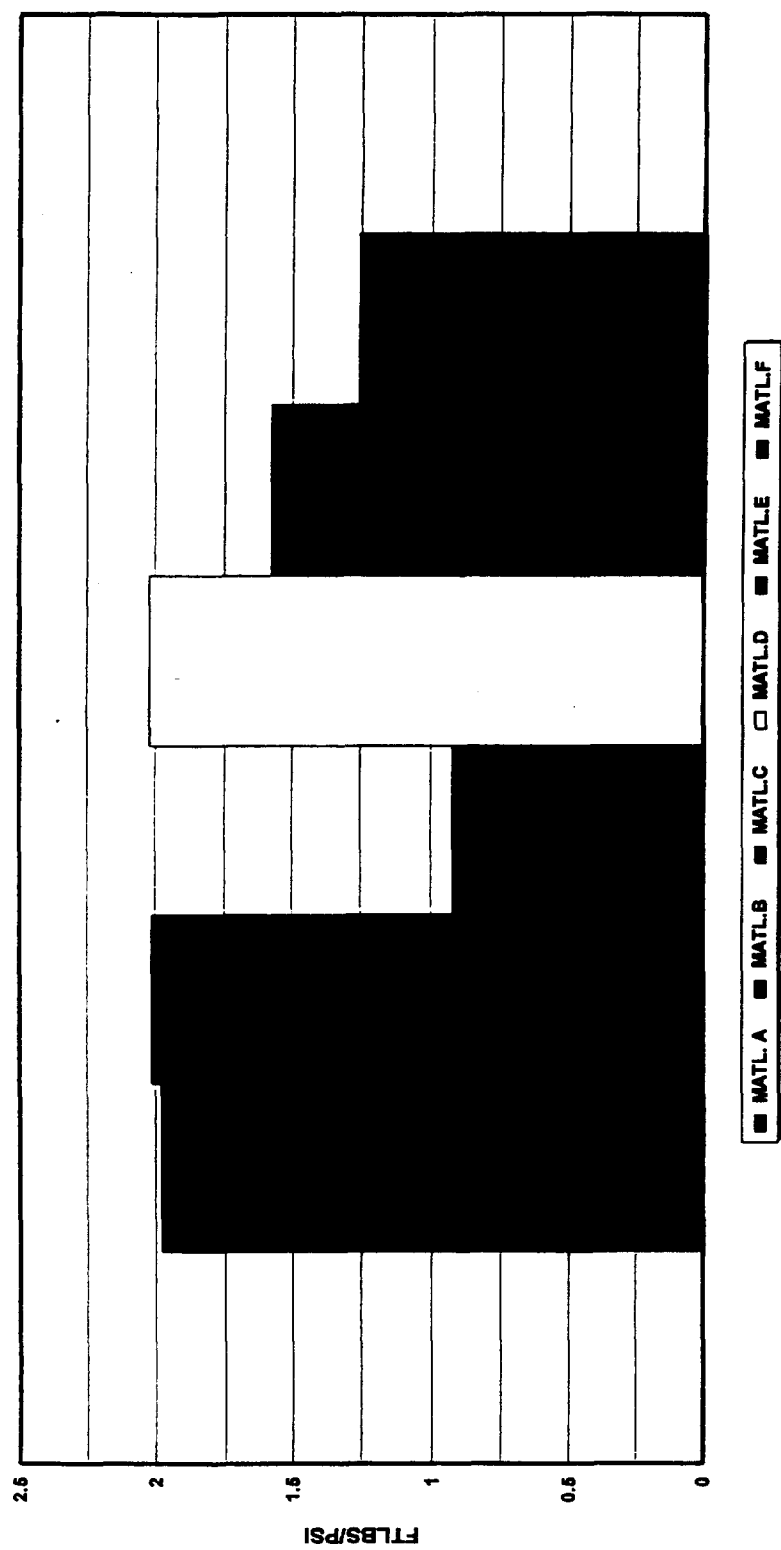


REGRESSED SPECIFIC TORQUE
LNK TESTING DATA

FIGURE 1

SAE J1652 COMPARISON OF COMMERCIAL DISC PRODUCTS

FMSI D-52, CHEVY CAPRICE



REGRESSED SPECIFIC TORQUE
GTL TEST DATA

V) J2430 VALIDATION TESTING

1. TOTAL PROGRAM

- ** OE & AFTERMARKET DISC & DRUM LININGS**
- ** 250+ DYNAMOMETER TESTS--GREENING & LINK TESTING**
- ** 12 INSTRUMENTED VEHICLE TESTS--GM & LINK WEST**

2. DIFFERENTIATE AMONG MATERIALS

- ** FIGURES 1 & 2 SUMMARIZE RESULTS FOR SEVERAL COMMERCIAL AFTERMARKET DISC & DRUM LININGS**

3. TEST/TEST

- ** FIGURES 3 & 4 SHOW DETAILS OF DUPLICATE J2430 TESTS ON DISC AND DRUM LININGS.**

3. LAB/LAB

- ** FIGURE 5 SHOWS A COMPARISON OF LINK & GREENING RESULTS FOR THE FORD EXPLORER FRONT DISC BRAKE**

4. DYNAMOMETER/VEHICLE

- ** FIGURE 6 SUMMARIZES DYNAMOMETER/VEHICLE CORRELATION FOR THE BRAKES TESTED.**
- ** 1997 HONDA CIVIC; 1997 CARAVAN; 1997 GRAND PRIX; 1998 EXPLORER; 1998 F250.**