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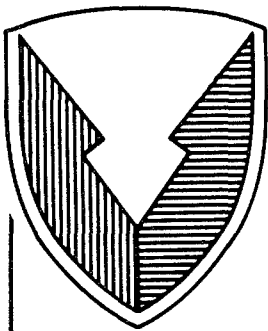
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R D & E

C E N T E R

Technical Report



No. 13270

DEVELOPMENT OF COST-EFFECTIVE
MANUFACTURING PROCESS FOR PRODUCING
CERAMIC TURBOCHARGER ROTORS

CONTRACT NUMBER DAAE 07-85-C-R 147

VOLUME 2 OF 2 (APPENDIX)

AUGUST, 1987

Robert J. Kobayashi, Robert L. Mullen
Donald E. Baker
Garrett Automotive Group,
Allied/Signal Corporation
3201 W. Lomita Blvd.
Torrance, CA 90501

and

Dr. Hun C. Yeh
AiResearch Casting Company
Allied/Signal Corporation
19800 Van Ness Ave.

By Torrance, CA 90509

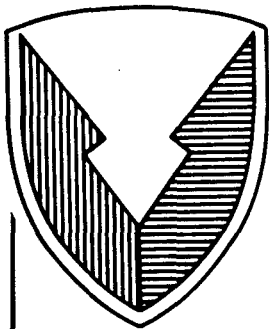
U.S. ARMY TANK-AUTOMOTIVE COMMAND
RESEARCH, DEVELOPMENT & ENGINEERING CENTER
Warren, Michigan 48397-5000

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RD & E

C E N T E R

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Torrance, CA 90509

By

Torrance, CA 90509

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RESEARCH, DEVELOPMENT & ENGINEERING CENTER
Warren, Michigan 48397-5000

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APPENDIX A

PARTS LISTS

DEVELOPMENT PARTS LIST

TV81

OUTLINE NUMBER 465703 REVISION JUN-02-1987

MPL 44

SALES ORDER 4- 3300 PURCHASE ORDER

SERIAL NO TAC1 THRU TAC8

APPLICATION: TACOM TV81/CERAMIC WHEEL

COMPRESSOR TRIM A3 ()

A ANGLE =

EPSILON ANGLE =

TURBINE TRIM F () TURBINE A/R 1.39

BETA ANGLE =

DELTA ANGLE =

LINE NO.	PART NUMBER	CHG LTR	DRWG SIZE	ASS'Y ORDER	PARTS REQ'D	REMARKS
0001	465703-0001				01	TURBOCHARGER
0002						
0003	*445180-0001				01	CHRA
0004	408495-0024	Z			01	CENTER HSG ASSY
0005	408752-0003	T			01	HSG,CENTER
0006	408752-0011	Z			01	HSG,CENTER-CAST
0007						
0008	400860-0001	C			02	PIN,SPRING
0009	400860-0199				02	PIN,SPRING-UNTREATED
0010	408306-0060	E			01	BEARING,JOURNAL
0011						
0012	460565-0000				01	BRONZE BAR STOCK
0013	407135-0000	B			01	WASHER
0014	400408-0000	A			03	RING,RETAINING
0015						
0016	*443974-0001				01	TURBINE WHEEL ASSY
0017	*					
0018	*443971-0001				01	SHAFT
0019	*443972-0001				01	SLEEVE
0020	*443970-0001				01	WHEEL,TURBINE
0021	*443969-0001					WHEEL,TURBINE-CST
0022	*					CERAMIC
0023						
0024	404470-0000	N			01	COLLAR,THRUST
0025	408768-0001	M			01	SPACER,THRUST
0026	409132-0009	W			01	WHEEL,COMPRESSOR
0027	409132-0011	B			01	WHEEL,COMP-CAST
0028	400768-0013	M			01	LOCKNUT
0029						3/8-24
0030	408487-0024	Z			01	BACKPLATE ASSY
0031	408979-0021	S			01	BACKPLATE
0032	408979-0013	R			01	BACKPLATE-CAST
0033	406385-0000	F			01	BEARING,OUTBD THRUST
0034	406385-0999				01	BEARING,THRUST-BLANK
0035	400439-0001	C			03	SCREW,DRIVE
0036						NO. 0X.19 LG
0037	400424-0000	P			01	RING,SEAL
0038	400781-0702	A			04	BOLT
0039	400805-0205				04	BOLT

LINE NO.	PART NUMBER	CHG LTR	DRWG SIZE	ASS'Y ORDER	PARTS REQ'D	REMARKS
0040	408597-0000	C			04	PLATE,LOCK
0041	403818-0000	BM			02	RING,PISTON
0042	403818-0030	BK			01	RING,PISTON
0043						TURBINE END
0044	408593-0000	D			01	BEARING,INBD THRUST
0045	408593-0999				01	BEARING,THRUST-BLANK
0046	*445179-0001				01	SHROUD,WHEEL
0047	407657-0003	P			01	SHROUD,WHEEL-CAST
0048						
0049	409726-0015	U			01	HSG,COMPRESSOR
0050	409726-0959	U			01	HSG,COMP-CAST
0051						409726-0950 OPTIONAL
0052	443454-0795				01	COUPLING,V-BAND
0053	400580-0000	C			02	LOCKNUT
0054	400637-0560	L			01	COUPLING,V-BAND
0055						400560-0795 OPTIONAL
0056	408499-0045	U			01	HSG,TURBINE
0057	408499-0415	W			01	HSG,TURB-CAST
0058	400814-0202	C			02	SCREW,DRIVE
0059	408744-0000	B			01	NAMEPLATE
0110	*445178-0001				01	BEARING,JOURNAL
0113	*445177-0001				01	WASHER

TURBINE SIDE

DEVELOPMENT PARTS LIST

TV81

OUTLINE NUMBER 466032 REVISION

JUN-02-1987

MPL 44

SALES ORDER 4- 3300 PURCHASE ORDER

SERIAL NO TAC9

APPLICATION: TACOM TV81/METAL WHEEL

COMPRESSOR TRIM A3 ()

A ANGLE =

EPSILON ANGLE =

TURBINE TRIM F () TURBINE A/R 1.39

BETA ANGLE =

DELTA ANGLE =

LINE NO.	PART NUMBER	CHG LTR		DRWG SIZE	ASS'Y ORDER	PARTS REQ'D	REMARKS
0001	466038-0001	B	TURBOCHARGER				
0002							
0003	408742-0021	AW	CHRA			01	
0004	408495-0024	Z	CENTER HSG ASSY			01	
0005	408752-0003	T	HSG,CENTER			01	
0006	408752-0011	Z	HSG,CENTER-CAST			01	
0007							
0008	400860-0001	C	PIN,SPRING			02	
0009	400860-0199		PIN,SPRING-UNTREATED			02	
0010	408306-0000	E	BEARING,JOURNAL			02	
0011							
0012	460565-0000		BRONZE BAR STOCK			01	
0013	407135-0000	B	WASHER			02	
0014	400408-0000	A	RING,RETAINING			03	
0015							
0016	408492-0014	AL	TURBINE WHEEL ASSY			01	
0017	408453-0020	A	WHEEL ASSY-WELDED			01	
0018	406828-0006		SHAFT			01	
0019	406828-0126	B	SHAFT,COLD HEADED			01	
0020	407098-0012	W	WHEEL,TURBINE			01	
0021	407545-0002	R	WHEEL,TURBINE-CAST			01	
0022	407545-0102	P	WHEEL,TURB-CAST			01	UNFINISHED
0023							
0024	404470-0000	N	COLLAR,THRUST			01	
0025	408768-0001	M	SPACER,THRUST			01	
0026	409132-0009	W	WHEEL,COMPRESSOR			01	
0027	409132-0011	B	WHEEL,COMP-CAST			01	
0028	400768-0013	M	LOCKNUT			01	3/8-24
0029							
0030	408487-0024	Z	BACKPLATE ASSY			01	
0031	408979-0021	S	BACKPLATE			01	
0032	408979-0013	R	BACKPLATE-CAST			01	
0033	406385-0000	E	BEARING,OUTBD THRUST			01	
0034	406385-0999		BEARING,THRUST-BLANK			01	
0035	400438-0001	C	SCREW,DRIVE			03	NO. 0X.19 LG
0036							
0037	400424-0000	P	RING,SEAL			01	
0038	400781-0702	A	BOLT			04	1/4-20 X 1.0 LG
0039	400805-0205		BOLT			04	

LINE NO.	PART NUMBER	CHG LTR		DRWG SIZE	ASS'Y GRDFR	PARTS REQ'D	REMARKS
0040	408597-0000	C	PLATE,LOCK			04	
0041	403818-0000	BM	RING,PISTON			02	
0042	403818-0000	BK	RING,PISTON			01	TURBINE END
0043							
0044	408593-0000	D	BEARING,INBD THRUST			01	
0045	408593-0999		BEARING,THRUST-BLANK			01	
0046	407657-0004	P	SHROUD,WHEEL			01	
0047	407657-0003	P	SHROUD,WHEEL-CAST			01	
0048							
0049	409726-0015	U	HSG,COMPRESSOR			01	
0050	409726-0959	U	HSG,COMP-CAST			01	409726-0950 OPTIONAL
0051							
0052	443454-0795		COUPLING,V-BAND			01	400560-0795 OPTIONAL
0053	400580-0000	C	LOCKNUT			02	1/4-28
0054	400637-0560	L	COUPLING,V-BAND			01	
0055							
0056	408499-0045	U	HSG,TURBINE			01	
0057	408499-0415	W	HSG,TURB-CAST			01	A/R=1.39 442106-130P
0058	400814-0202	C	SCREW,DRIVE			02	.373 X .25 LG
0059	408744-0000	B	NAMEPLATE			01	

APPENDIX B

TEST DATA – HOT SPIN TEST

GARRETT

LABORATORY TEST LOG

FORM 2880 R

TEST = HOT SPIN

TV81 CERAMIC

TAC001

2-17-87

ARTICLE ON TEST

S/N

E.W.O/CHGE. NO.

3310-95-790

SUPP. Bob Mullen

I.D. 876029

P/N

BM59471

TECHNICIAN

W. Pearson

DATA
SHEET

1

LOG

SHEET

1

[illegible]

PAGE TIME: _____

TOTAL TIME: _____

GARRETT

LABORATORY TEST LOG

TEST = HOT SPIN

FORM 2880 R

FORM 2880 R
ARTICLE ON TEST TV81 CERAMIC S/N TAC002 DATE 2-17-87

E.W.O/CHGE. NO. 3310-95-790 SUPP. Bob Mullen I.D. 876029

P/N BM59471 TECHNICIAN W. Pearson DATA SHEET 1 LOG SHEET 1

[illegible]

PAGE TIME: _____

TOTAL TIME: _____

GARRETT

LABORATORY TEST LOG

FORM 2880 R

TEST = HOT SPIN

ARTICLE ON TEST

TV81 CERAMIC

S/N

TAC003

DATE _____

2-16-87

E.W.O/CHGE. NO.

3310-95-790

SUPP.

Bob Mullen

I.D.

876029

P/N

BM59471

TECHNICIAN

W. Pearson

DATA
SHEET

1

LOG
SHEI

1

[illegible]

PAGE TIME: _____

TOTAL TIME: _____

GARRETT	AIRESEARCH INDUSTRIAL DIVISION LOS ANGELES AND TORRANCE, CALIFORNIA		DATE	PAGE 1 OF 1
	TITLE OIL BEARING CERAMIC WHEEL TURBOCHARGER INSPECTION SHEET		NO.	
			BY	

TURBO S/N TAC001
CUSTOMER TACOM
ENG. _____

CENTER HOUSING

BEARING BORE DIA. (TURB. END)	0.9831
BEARING BORE DIA. (COMP. END)	0.9829

BEARINGS BRONZE AL OTHER (CIRCLE ONE)

BEARING O.D. (TURB. END)	0.9785
BEARING O.D. (COMP. END)	0.9784
BEARING I.D. (TURB. END)	0.7015
BEARING I.D. (COMP. END)	0.6271

SHAFT WHEEL ASSEMBLY

TURBINE (END) SIDE JOURNAL DIA.	0.6997
COMP (END) SIDE JOURNAL DIA.	0.6253

C.H.R.A. BEARING CLEARANCES

PRINT
TOLERANCE

AT TURBINE BEARING O.D.	0.0046 (0.004/0.005)
COMP. BEARING O.D.	0.0045 (0.004/0.005)
TURBINE BEARING I.D.	0.0018 (0.0014/0.0022)
COMP. BEARING I.D.	0.0018 (0.0014/0.0022)

SHAFT WHEEL ASSEMBLY END PLAY	0.004
SHAFT WHEEL ASSEMBLY RADIAL PLAY	-
IMPELLER CLEARANCE RADIAL	0.017
IMPELLER CLEARANCE TIP	0.020
TURBINE CLEARANCE RADIAL	0.031
TURBINE CLEARANCE TIP	0.025

COMMENTS: _____

GARRETT**AIRESEARCH INDUSTRIAL DIVISION**

LOS ANGELES AND TORRANCE, CALIFORNIA

DATE

PAGE

1 OF 1

NO.

BY

TITLE

OIL BEARING CERAMIC WHEEL TURBOCHARGER
INSPECTION SHEETTURBO S/N TAC002CUSTOMER TACOM

ENG. _____

CENTER HOUSING

BEARING BORE DIA. (TURB. END)

0.9832

BEARING BORE DIA. (COMP. END)

0.9831/.9832BEARINGSBRONZE

AL

OTHER

(CIRCLE ONE)

BEARING O.D. (TURB. END)

0.97835

BEARING O.D. (COMP. END)

0.9785

BEARING I.D. (TURB. END)

0.7015

BEARING I.D. (COMP. END)

0.6271SHAFT WHEEL ASSEMBLY

TURBINE (END) SIDE JOURNAL DIA.

0.6998

COMP (END) SIDE JOURNAL DIA.

0.6253C.H.R.A. BEARING CLEARANCES

AT TURBINE BEARING O.D.

0.0048⁵

COMP. BEARING O.D.

0.0046/.0047

TURBINE BEARING I.D.

0.0017

COMP. BEARING I.D.

0.0018

SHAFT WHEEL ASSEMBLY END PLAY

0.004

SHAFT WHEEL ASSEMBLY RADIAL PLAY

-

IMPELLER CLEARANCE RADIAL

0.017

IMPELLER CLEARANCE TIP

0.021

TURBINE CLEARANCE RADIAL

0.032

TURBINE CLEARANCE TIP

0.024

COMMENTS: _____

GARRETT**AIRESEARCH INDUSTRIAL DIVISION**

LOS ANGELES AND TORRANCE, CALIFORNIA

DATE

PAGE

1 OF 1

NO.

TITLE

OIL BEARING CERAMIC WHEEL TURBOCHARGER
INSPECTION SHEET

BY

TURBO S/N TAC003CUSTOMER TACOM

ENG. _____

CENTER HOUSINGBEARING BORE DIA. (TURB. END) 0.9830BEARING BORE DIA. (COMP. END) 0.9829BEARINGS BRONZE AL OTHER (CIRCLE ONE)BEARING O.D. (TURB. END) 0.9784/0.9785BEARING O.D. (COMP. END) 0.97845BEARING I.D. (TURB. END) 0.7016BEARING I.D. (COMP. END) 0.62715SHAFT WHEEL ASSEMBLYTURBINE (END) SIDE JOURNAL DIA. 0.6998/0.6999COMP (END) SIDE JOURNAL DIA. 0.6253C.H.R.A. BEARING CLEARANCESAT TURBINE BEARING O.D. 0.0045/0.0046COMP. BEARING O.D. 0.0044⁵TURBINE BEARING I.D. 0.0017/0.0018COMP. BEARING I.D. 0.0018⁵SHAFT WHEEL ASSEMBLY END PLAY 0.004SHAFT WHEEL ASSEMBLY RADIAL PLAY -IMPELLER CLEARANCE RADIAL 0.016IMPELLER CLEARANCE TIP 0.019TURBINE CLEARANCE RADIAL 0.032TURBINE CLEARANCE TIP 0.024

COMMENTS: _____

APPENDIX C

TEST DATA – AERODYNAMIC PERFORMANCE

GARRETT	AIRESEARCH INDUSTRIAL DIVISION LOS ANGELES AND TORRANCE, CALIFORNIA		DATE	PAGE 1 OF 1
	TITLE OIL BEARING CERAMIC WHEEL TURBOCHARGER INSPECTION SHEET		NO.	
			BY	

TURBO S/N TAC007
CUSTOMER TACOM
ENG. _____

CENTER HOUSING

BEARING BORE DIA. (TURB. END)	0.98305
BEARING BORE DIA. (COMP. END)	0.98290

BEARINGS BRONZE AL OTHER (CIRCLE ONE)

BEARING O.D. (TURB. END)	0.9785
BEARING O.D. (COMP. END)	0.9785
BEARING I.D. (TURB. END)	0.7015
BEARING I.D. (COMP. END)	0.6271

SHAFT WHEEL ASSEMBLY

TURBINE (END) SIDE JOURNAL DIA.	0.6998
COMP (END) SIDE JOURNAL DIA.	0.6252

C.H.R.A. BEARING CLEARANCES

AT TURBINE BEARING O.D.	0.0045 ⁵
COMP. BEARING O.D.	0.0044
TURBINE BEARING I.D.	0.0017
COMP. BEARING I.D.	0.0019

SHAFT WHEEL ASSEMBLY END PLAY	0.004
SHAFT WHEEL ASSEMBLY RADIAL PLAY	-

IMPELLER CLEARANCE RADIAL	0.017
IMPELLER CLEARANCE TIP	0.020
TURBINE CLEARANCE RADIAL	0.032 (0.032) *
TURBINE CLEARANCE TIP	0.025 (0.024) *

COMMENTS: * (DIM) = CLEARANCE WITH TAC007 CHRA MOUNTED IN TAC009

TURB. HS'G FOR GAS STAND T.I.056 TEST.

GARRETT	AIRESEARCH INDUSTRIAL DIVISION LOS ANGELES AND TORRANCE, CALIFORNIA	DATE	PAGE 1 OF 1
	TITLE	NO.	
	OIL BEARING METAL WHEEL TURBOCHARGER INSPECTION SHEET	BY	

TURBO S/N TAC009 CUSTOMER TACOM ENG. _____

CENTER HOUSING

BEARING BORE DIA. (TURB. END) 0.98290

BEARING BORE DIA. (COMP. END) 0.98280

BEARINGS BRONZE AL OTHER (CIRCLE ONE)

BEARING O.D. (TURB. END) 0.97840

BEARING O.D. (COMP. END) 0.97855

BEARING I.D. (TURB. END) 0.62715

BEARING I.D. (COMP. END) 0.6271

SHAFT WHEEL ASSEMBLY

TURBINE (END) SIDE JOURNAL DIA. 0.6251

COMP (END) SIDE JOURNAL DIA. 0.6252

C.H.R.A. BEARING CLEARANCES

AT TURBINE BEARING O.D. 0.0045

COMP. BEARING O.D. 0.0042⁵

TURBINE BEARING I.D. 0.0020⁵

COMP. BEARING I.D. 0.0019

SHAFT WHEEL ASSEMBLY END PLAY 0.004

SHAFT WHEEL ASSEMBLY RADIAL PLAY -

IMPELLER CLEARANCE RADIAL 0.016

IMPELLER CLEARANCE TIP 0.021

TURBINE CLEARANCE RADIAL 0.030 (0.031) *

TURBINE CLEARANCE TIP 0.024 (0.025) *

COMMENTS: *(DIM.) = 2ND TIME MEASURED. GAS STAND PERF. TI056 -

METAL WHEEL

GAS STAND PERFORMANCE TEST
"TIGHT WH'L CLEARANCE FOR CERAMIC WH'L"

DIESEL TURBOCHARGER
PREPRODUCTION ASSEMBLY RECORD

GARRETT

DATE

MODEL NO.		TACOM/TV81		SALES ORDER NO.		CUSTOMER		PART NO.		DATE	
TURBOCHARGER SERIAL NUMBER		TAC07		TAC09							
AXIAL END PLAY		0.004		0.004							
COMPRESSOR RADIAL CLEARANCE		0.017		0.018							
COMPRESSOR TIP CLEARANCE		0.022		0.022							
TURBINE RADIAL CLEARANCE		0.021		0.032							
TURBINE TIP CLEARANCE		0.023		0.027							
SHAFT STRETCH		0.010		0.010							
VSR READING											
ORIENTATION		α									
		β									
		ω									
		δ									
		γ									
		CERAMIC WH'L		METAL WH'L							
ASSEMBLER		DATE		ENGINEERING		DATE		INSPECTION		DATE	

NUMBER

TI 056

REV.

F**TITLE:**

TEST INSTRUCTION 056
COMPONENT TEST CELL

PAGE 1 OF 11

PRODUCT:

DRAWN

CHK

APPROVED

APPROVED

APPROVED

APPROVED

REVISIONS

[illegible]

GARRETT	AIRESEARCH INDUSTRIAL DIVISION LOS ANGELES AND TORRANCE, CALIFORNIA	DATE 1-30-75	PAGE 2 OF 11
	TITLE COMPONENT TEST CELL	NO. TI 056	
		BY A. McCutcheon	

A. TYPE OF TEST (Check One) _____ Compressor
Compressor & Turbine

Thermocouple checkout (yes/no). For instructions, see Section J.

Record additional compressor pressure (yes/no). For instructions, see Section K.

Zero all manometers.

Thermally insulate the unit between the compressor housing discharge and the compressor discharge thermocouples and also between the turbine inlet thermocouples and the turbine housing inlet flange.

B. TEST CONSTANTS

T_{1T}/T_{1C} _____ (Compressor & Turbine Test Only)

T_{1T} _____ (Compressor Test Only)

Use	Compressor Flow Nozzle
-----	------------------------

Use Turbine Flow Nozzle

Run the following speed lines consecutively unless otherwise instructed. See Page 2 for actual speeds and choke flow P_{S6} settings.

1 2 3 4 5 6 7 8 9 (Circle applicable speeds)

Number of data points per speed line

Do/do not record an additional point with the compressor throttle valve fully open on speed lines 1 2 3 4 5 6 7 8 9.

Do not surge at speed line(s) _____ and set
maximum P_{S5} at _____ inHg ± 0.5

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NO. TI 056

TITLE

COMPONENT TEST CELL

BY
A. McCutcheon**C. TURBOCHARGER INFORMATION**

Model _____ S/N _____ Outline _____

Impeller P/N & S/N _____ Turbine Shaft Assy P/N _____

S/N _____

Diffuser P/N & S/N _____ Nozzle P/N & S/N _____

Housing P/N & S/N _____ Housing P/N & S/N _____

Comp. Housing A/R _____ Turb. Housing A/R _____

Existing Map No. _____ Existing Map No. _____

 D_T _____ in. D_{TT} _____ in. _____ D_1 _____ in. A_N _____ sq. in. B_{TT} _____ in. D_H _____ in.**D. ENGINEER _____ DATE _____**

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LOS ANGELES AND TORRANCE, CALIFORNIADATE
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NO. TI 056

TITLE

COMPONENT TEST CELL

BY
A. McCutcheonC. TURBOCHARGER INFORMATION

Model _____ S/N _____ Outline _____

Impeller P/N & S/N _____ Turbine Shaft Assy P/N _____

S/N _____

Diffuser P/N & S/N _____ Nozzle P/N & S/N _____

Housing P/N & S/N _____ Housing P/N & S/N _____

Comp. Housing A/R _____ Turb. Housing A/R _____

Existing Map No. _____ Existing Map No. _____

 D_T _____ in. D_{TT} _____ in. _____ D_1 _____ in. A_N _____ sq. in. B_{TT} _____ in. D_H _____ in.

D. ENGINEER _____ DATE _____

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BY A. McCutcheon

E. Standard test speeds corrected to 85°F compressor inlet air temperature, and pressure setting for maximum flow data point. Speeds shown are revolutions per minute (rpm) and pressure are inches mercury gage (in. HgG) measured at the upstream flow element position (P_{g6} manometer).

Turbo	Speedline Group	Speedline Number								
		1	2	3	4	5	6	7	8	9
T-2 BCCW 48 mm (1.890)	1	70,700 3.0	99,000 7.0	120,800 12.0	138,100 16.0	152,900 21.0	166,400 25.5	179,900 28.0	192,800 33.0	
T-3 BCCW 60 mm (2.370)	2	56,400 1.0	78,900 7.0	96,300 12.0	110,200 16.0	121,900 21.0	132,700 25.5	143,500 28.0	153,700 33.0	
T-3 BCCW 69 mm (2.717)	3	51,200 3.3	74,300 7.6	90,200 12.5	103,200 16.8	113,700 21.7	123,200 26.2	131,900 29.4	139,900 34.2	
T4, T04B, T04B BCCW	4	46,100 3.5	69,700 8.1	84,000 13.0	96,300 17.6	105,500 22.3	113,700 26.9	120,400 30.7	126,000 35.4	
T45 BCCW 84 mm (3.307)	5	42,500 3.5	60,200 8.0	73,800 13.0	85,200 17.5	95,300 22.0	104,300 31.0	112,700 36.0		
T51 BCCW 91 mm (3.583)	6	41,000 3.5	56,200 8.0	67,900 13.0	78,100 17.5	87,000 22.0	95,000 31.0	102,500 36.0		
TE06/T12 TV60, TV61, TV61 BCCW	7	41,000 3.5	51,200 5.5	63,500 9.5	71,500 12.8	79,400 16.0	87,400 21.1	95,300 29.9	102,500 39.1	110,200 49.6
T12, TV70, TV71, BCCW, TV71 TV77	8	35,900 3.5	45,100 5.5	55,300 11.0	65,100 13.5	74,800 19.5	85,100 26.0	95,300 35.5	105,500 47.0	
TH08A, TV81, *T18, TV81, TV81 BCCW	9	32,800 3.5	45,100 7.2	55,300 13.0	66,600 19.0	75,800 26.4	84,000 37.6	91,200 46.8	99,400 66.7	
*T18, T18A, T19, TV91	10	28,700 3.5	37,900 7.2	47,100 13.0	56,400 19.0	63,500 26.4	70,700 37.6	77,900 46.8	85,100 66.7	
T24	11	24,600 3.5	32,800 7.2	41,000 13.0	49,200 19.0	55,300 26.4	61,500 37.4	67,600 46.8	73,800 66.7	

*T18 With 4.25" Compressor Wheel

**T18 With 5.00" Compressor Wheel

F. OBSERVE SURGE POINTS - CHART DELETED

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G. TEST INSTRUCTIONS

1. After combustor light-off, adjust gas and air to bring turbocharger up to Speedline #1. For all data points, the tolerance on speed is $\pm 1\%$ and $\pm 5^\circ$ on turbine inlet temperature.
2. While maintaining speed and temperature, close throttle valve until compressor surge is experienced. Surge the turbocharger two to three times, being sure that speed is correct and read the P_{S5} and ΔP_{S5} manometers at surge. The compressor flow orifice or nozzle must be the largest available diameter that results in a ΔP_{S6} reading at surge of at least 4.0 in H_2O .
3. Open throttle valve while maintaining speed and temperature until P_{S6} , listed in Section E, page 3, of this test instruction, is reached (± 0.5 in Hg), or until the throttle valve is wide open (if this results in the P_{S6} reading being greater than that listed in Section E). Operate at this maximum flow point for five minutes before recording any data. After five minutes, check to be sure T_{Q1} has not changed (if so, speed may need to be changed slightly). Thermal stability can be assumed when the "tenths" digit of the Doric for the T05 measurement remains steady or flickers between the same two numbers for at least 30 seconds. Record data for this point.
4. Determine the spacing of the remaining data points by using the values of ΔP_{S6} at surge and maximum flows. This is best accomplished by using the logarithmic ΔP_{S6} chart and an evenly-graduated scale. Place the scale on the chart so that the surge point and maximum flow point ΔP_{S6} values are connected, rotating the scale until the correct number of graduations are obtained to satisfy the number of data points per speedline (Section B, page 1). At each graduation, the correct ΔP_{S6} setting will be indicated for a data point. If data is being collected by the computerized Data Acquisition System, the computer will perform this calculation and display the ΔP_{S6} setting for the next point. Refer to the Data Acquisition System Operating Manual (EDI 073).

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5. Run the remaining data points in order of decreasing ΔP_{S6} . Starting from the maximum flow point, close the throttle valve, readjusting the gas and air valves as required, until the next ΔP_{S6} (from step #4, above) is reached. While this point is stabilizing, calculate and plot $\frac{T_{05} - T_{01}}{T_{01} + 460}$ versus ΔP_{S6} for the preceeding point

on the Thermal Data Check Plot form (if data is being collected by the Data Acquisition System, the calculation will be performed by the computer). After checking that speed and temperatures are within specifications, record another line of data. Continue closing the throttle and recording data until the surge point is reached. Continue plotting $\frac{T_{05} - T_{01}}{T_{01} + 460}$

ΔP_{S6} (also known as $\Delta T/T$ or "delta T over T" versus "corrected" ΔP) for each point. The resulting line should be smooth, although not necessarily flat. $\Delta T/T$ points that vary by more than ± 0.05 (one graduation on the Check Plot form) indicate suspicious temperature data and the point must be rerun.

NOTE: $\Delta T/T$ versus ΔP_{S6} may be plotted at the end of each speed line after consulting with engineer in charge of unit.

6. Redetermine the surge point by surging the compressor two or three times. It is possible that the surge point may have changed slightly. For the last data point, try to operate the turbocharger at a stable point as near surge as practical. Generally, it is possible to operate at least within 0.1 in H_2O (ΔP_{S6}) of surge. Mark the surge point on the data sheet with the letter "S" in the blank space in between the compressor and turbine data sections. If it has been necessary to change from an Hg manometer to a psig gage, note the change in the blank section of the data sheet.
7. After rechecking the Hg barometer (this should be done at least once for every speed line), proceed to the next speed line and repeat items #1 through #7 until all speed lines have been completed. If compressor surge point is not required on some of the high speed lines, the engineer will supply maximum values of P_{S5} , see Section B, page 1, of this test instruction. Do not surge unit, go immediately to the maximum flow

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point, stabilize for five minutes, and record the first set of data. Determine data point spacing upon the basis of P_{S5} . Starting with P_{S5} at the maximum flow point and given the maximum P_{S5} , run the remaining data points at evenly-spaced P_{S5} values. Thus, at the last data point, the specified maximum P_{S5} will have just been reached. Other than this different method of spacing data points and the omission of compressor surging, the procedure outlines in Steps #1 through #6 should be followed.

H. COMPRESSOR INSTABILITY

Compressor instability can be thought of as "mild" compressor surge. Compressor surging refers to "momentary flow reversal" with the compressor. Surging is accompanied by audible "popping" and/or "hissing" noises, and the pressure manometers usually fluctuate violently. Compressor instability may, or may not be experienced during turbocharger testing, depending upon the turbocharger model and the test speed. Strange "moaning" or "hissing" noises may be heard and the manometers will quiver and jump slightly. Generally, if instability is present in a particular compressor, it will be found as surge is approached; that is, starting at the maximum flow point, as the throttle valve is closed, a point will be reached where the manometers will demonstrate a marked unsteadiness.

We are vitally interested in knowing where compressor instability occurs. Because each compressor reacts a little differently in regards to instability, and many do not show any signs of it at all; it may be hard to know exactly when you have reached the instability region of compressor operation. For purposes of test standardization, compressor instability will be defined as "that operating point where a definite increase in manometer fluctuation is first observed". The P_{S6} manometer will generally be most sensitive to instability. Should there be any question, call the responsible test engineer.

If instability is observed during testing, the data point flow spacing previously set need not be followed. A data point should be established at the instability point and full data recorded. The data sheet should be marked with an "I" and the range of fluctuation of the manometer noted in the blank space between the compressor and turbine data

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sections. Remaining data points between instability and surge should be equally spaced using ΔP_{S6} . Data points between instability and surge shall be recorded so long as the maximum fluctuation in P_{S5} does not exceed $\pm 3/4$ in. Hg from an "average" position. Should it be found that turbocharger speed is fluctuating and cannot be held within $\pm 2\%$, no more data points except surge should be recorded.

Obviously, with fluctuation in test conditions, it can be argued that any data obtained is erroneous. This is not necessarily so, it is much better to have a rough idea of the instability region than no knowledge at all. It should also be mentioned that simply because the test engineer's request states "six data points per speed line" does not mean that additional data points required to help define a peculiar area of turbocharger operation are unwelcome. Ultimately, the validity of the test data is the responsibility of the test engineer, and the test cell operator will never be censured for doing too good of a job.

I. USE OF ADDITIONAL COMPRESSOR PRESSURE TAPS

Occasionally, additional pressure taps will be used to monitor the performance of specific elements of the compressor/diffuser system. When this is done, the pressure lines are generally routed through a system of toggle valves and rotary valves to a manometer on the console sidewall.

The data will be recorded on the Supplementary Pressure Tap Data Sheets provided.

J. THERMOCOUPLE CHECKOUT

The purposes of this checkout is to ensure the continuity of the temperature measurement system. This will be done by manually recording each of the Doric temperature readouts before unit "start up".

K. PRESSURE CHECKING PROCEDURE

The prime object of this procedure is to insure that there are no leaks in the instruments and associated lines.

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1. Instrumentation

- a. Disconnect all instrumentation lines from piping.
- b. Manifold instrumentation lines together.
 - (i) Zero all manometers.
- c. Pressurize manifold to approximately 60 in. Hg and seal the manifold.
- d. Let stand for 10 minutes.
 - (i) No pressure decay is allowed.
 - (ii) If any pressure decay is encountered, trace and eliminate leaks.
- e. If more than one manometer will be used for any parameter, make sure to test extra manometers. Also test any gages which may be used to measure pressures in excess of 100 in. Hg.

2. Test Cell Piping

- a. Disconnect all instrumentation lines from piping and cap all fittings except those on flow nozzles.
- b. Through a 2-way, 2-position valve, connect flow nozzles to a Heise (or equivalent) gage. (Range: 0-200 in. HgG; least count: 0.2). Zero the gage.
- c. Place a block-off plate at the upstream flange of the compressor outlet flow control valve. Disconnect bypass valve on upstream side and seal the opening in the pipe.
- d. Connect the turbine flange adaptor to the compressor outlet adaptor through 2 valves so as to allow bleeding both systems as well as isolation of both systems.

At this point, be certain that all manometers are disconnected from piping; also that gage being used has sufficient capacity.

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- e. Pressurize both systems to approximately 130 in. HgG (or whatever the prevailing air supply pressure is at the time) using the Masoneilan valve.
- f. Close the Masoneilan valve.
- g. Isolate the turbine piping from the compressor piping by closing the appropriate valve.
- h. Let stand for 10 minutes.
 - (i) If at the end of 1 minute the pressure decay exceeds
 - Compressor side - 0.5 in. Hg
 - Turbine side - 0.35 in. Hg
 inspect for leaks and repair.
 - (ii) If at the end of 10 minutes the pressure decay exceeds
 - Compressor side - 5.0 in. Hg
 - Turbine side - 3.5 in. Hg
 inspect for leaks and repair. Check leakage rate again.
- i. Drain systems.
- j. Reconnect all instrumentation lines.

3. Turbocharger/Cell Interface

- a. Mount turbocharger.
 - (i) Seal oil inlet and outlet.
- b. Seal and connect turbine outlet and compressor inlet.
- c. Pressurize entire system to 60 in. Hg.

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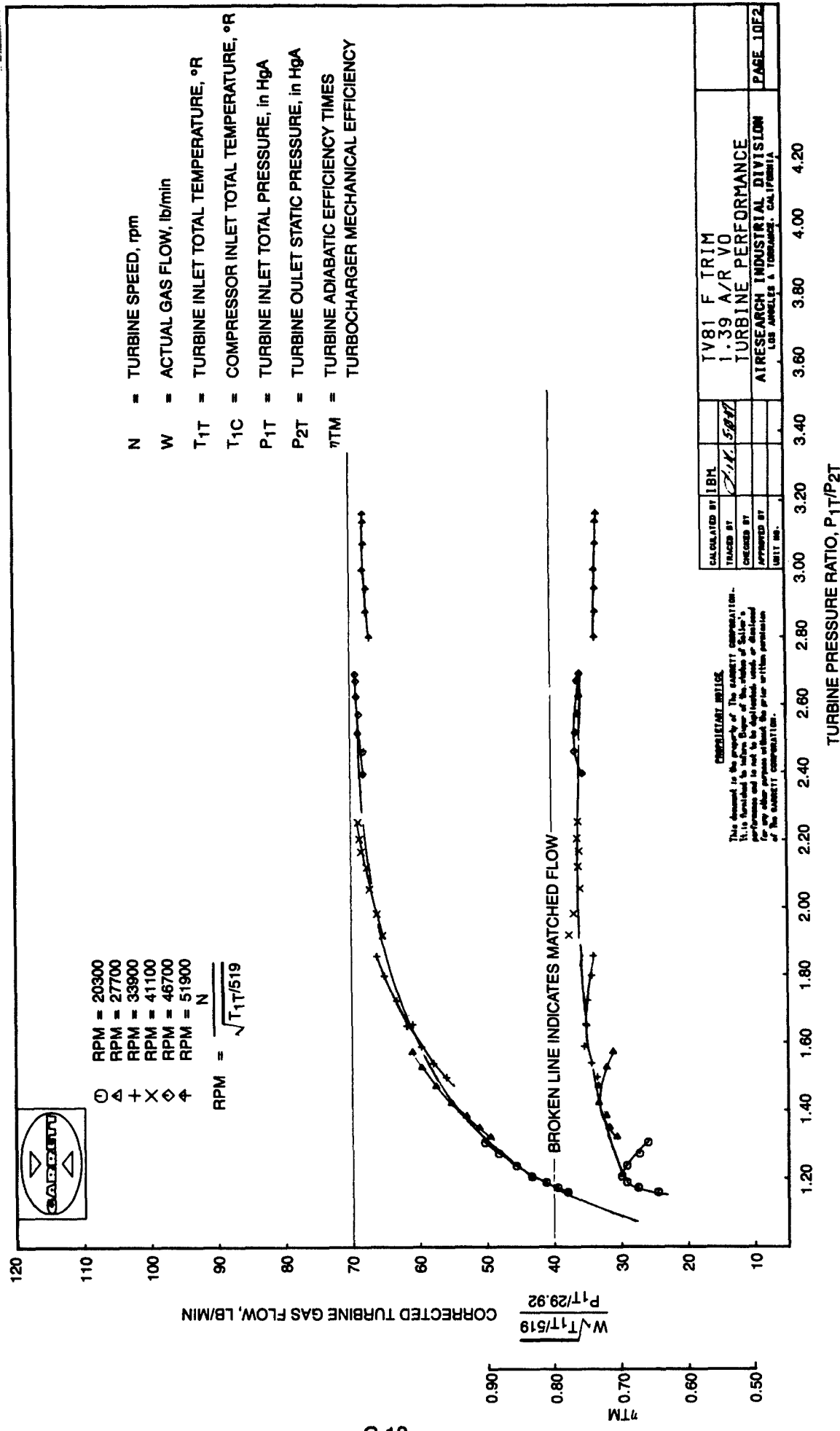
BY
A. McCutcheon

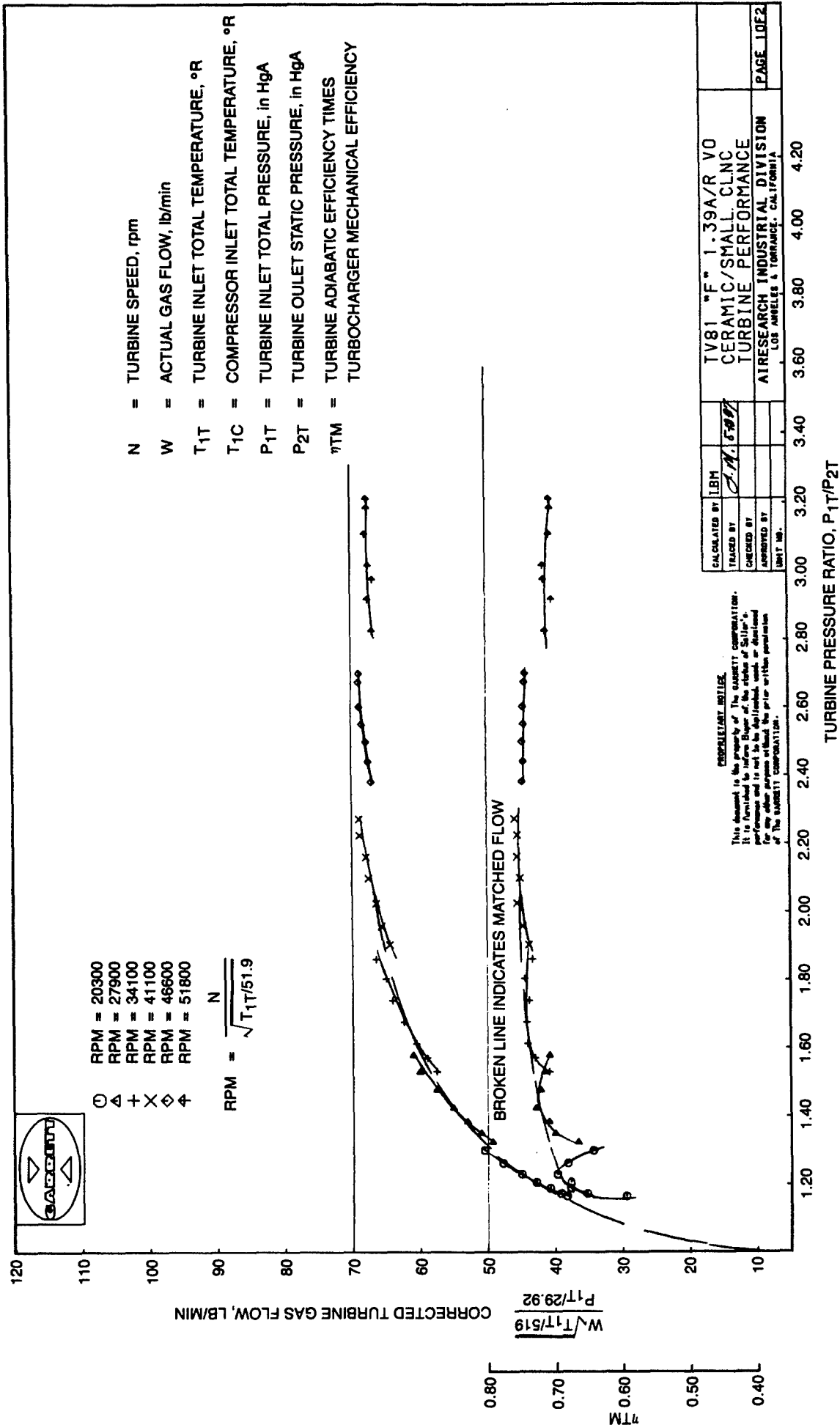
- d. Use leak detecting solution on:
- (i) All instrument line connections to cell piping.
 - (ii) Turbine inlet.
 - (iii) Compressor outlet.
 - (iv) Static tap connections at compressor housing.
 - (v) Repair any leaks found.
- e. Remove block-off plate upstream of control valve and re-install bypass valve.
- f. Mount compressor inlet and turbine outlet piping.
- g. Hook up turbocharger oil supply lines.

A.R.S. McCutcheon

ARSM/klh

Revision	Description	Date	Approval
A	G5; K	6 Jan 77	
B	Replace Page 3 of 9	17 May 78	





CALCULATED BY	IBM	TV81 "F" 1-39A/R V0
TRACED BY	J.H. 5-10-67	CERAMIC/SMALL CLNC
CHECKED BY		TURBINE PERFORMANCE
APPROVED BY		ATRESEARCH INDUSTRIAL DIVISION
UNIT NO.		LOS ANGELES & TORRANCE, CALIFORNIA
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APPENDIX D

TEST DATA – SHAFT MOTION

5.1.4 Shaft Motion

Test Procedure:

Instrumentation:

Two Bently proximity probes

Two Matched proximeter transducers

One oscilloscope with X-Y capability (Lissajous) equipped with Polaroid camera capable of taking pictures with 1/50 sec. and 10 sec. exposure times.

One Nicolet 444A frequency analyzer

One X-Y plotter

Test Instructions:

1. Install test unit on a Lomita laboratory gas stand. Turbocharger lubricant to be SAE 30 weight oil at inlet condition of 200 F and 40 psig.
2. Roll-over with cold air, light burner and stabilize at lowest speed possible without burner flameout at an inlet temperature of 1000 F.
3. Increase speed at the rate of 10,000 RPM per minute until 80,000 RPM is reached. Monitor speed while accelerating to document failure speed in the event of a problem. Set compressor discharge valve to operate midway between choke and surge.
4. Shutdown unit and install shaft motion instrumentation. Calibrate so that 1 cm on the scope screen is 0.005 inch of radial shaft movement. Determine static shaft excursion limits by manually moving the rotating assembly in a conical motion while photographing the scope screen.
5. Restart unit and make a speed sweep from minimum speed to 80,000 RPM at a rate of 20,000 RPM per minute. Plot total and synchronous shaft motion as a function of speed.
6. Examine the total and synchronous motion traces to identify rotational speeds at which peaks or instability occur. Dwell the unit at each identified speed and plot shaft motion frequency analysis. Photograph scope screen. Multiple records should be made if motion characteristics are unstable.
7. Shut unit down and, when cool, recheck static excursion limits per item 4.

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	OIL BEARING CERAMIC WHEEL TURBOCHARGER INSPECTION SHEET	BY	

TURBO S/N TAC008 CUSTOMER TACOM ENG. _____

CENTER HOUSING

BEARING BORE DIA. (TURB. END) 0.98310

BEARING BORE DIA. (COMP. END) 0.98305

BEARINGS BRONZE AL OTHER (CIRCLE ONE)

BEARING O.D. (TURB. END) 0.9785

BEARING O.D. (COMP. END) 0.9785

BEARING I.D. (TURB. END) 0.7016

BEARING I.D. (COMP. END) 0.6271

SHAFT WHEEL ASSEMBLY

TURBINE (END) SIDE JOURNAL DIA. 0.6996

COMP (END) SIDE JOURNAL DIA. 0.6251

C.H.R.A. BEARING CLEARANCES

AT TURBINE BEARING O.D. 0.0046

COMP. BEARING O.D. 0.0045⁵

TURBINE BEARING I.D. 0.0020

COMP. BEARING I.D. 0.0020

SHAFT WHEEL ASSEMBLY END PLAY 0.004

SHAFT WHEEL ASSEMBLY RADIAL PLAY -

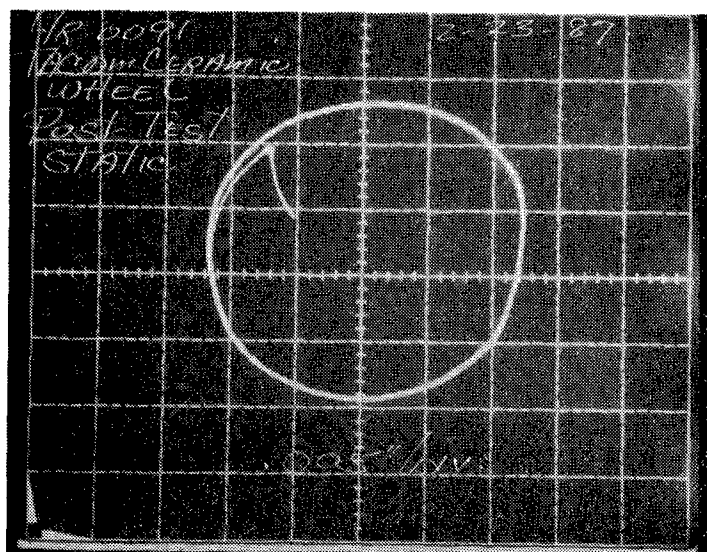
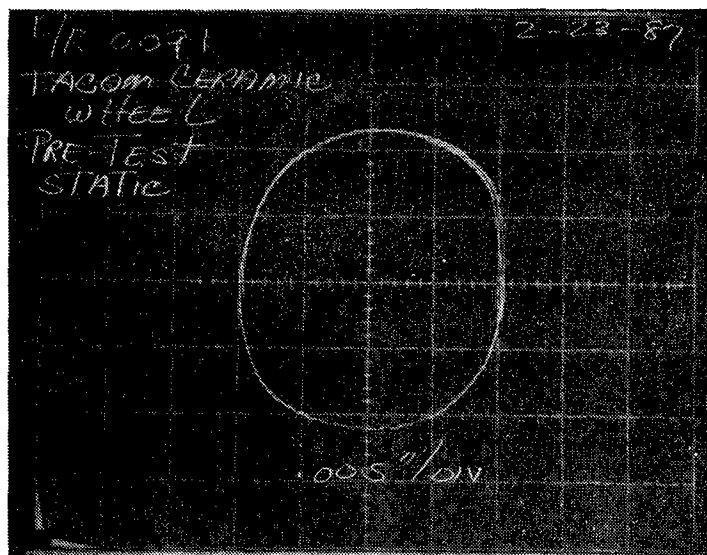
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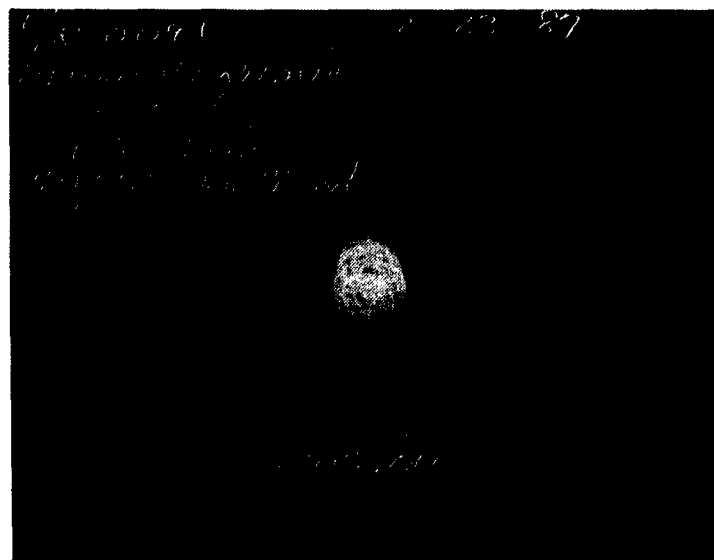
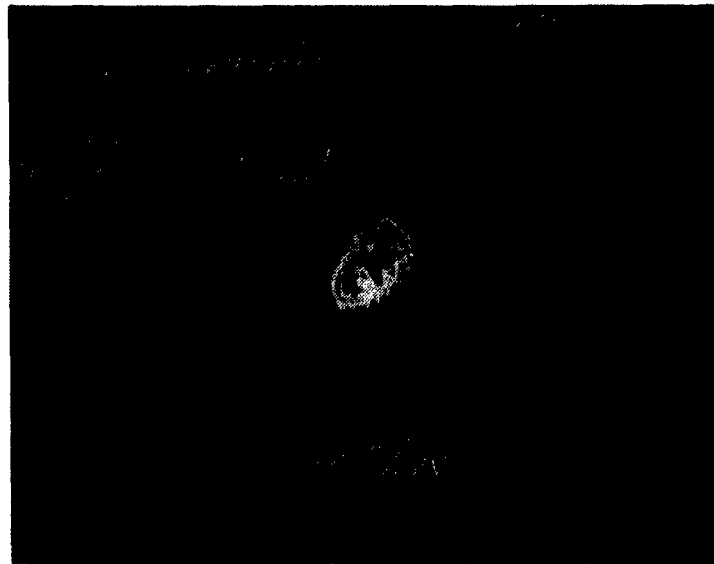
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TURBINE CLEARANCE RADIAL 0.032

TURBINE CLEARANCE TIP 0.024

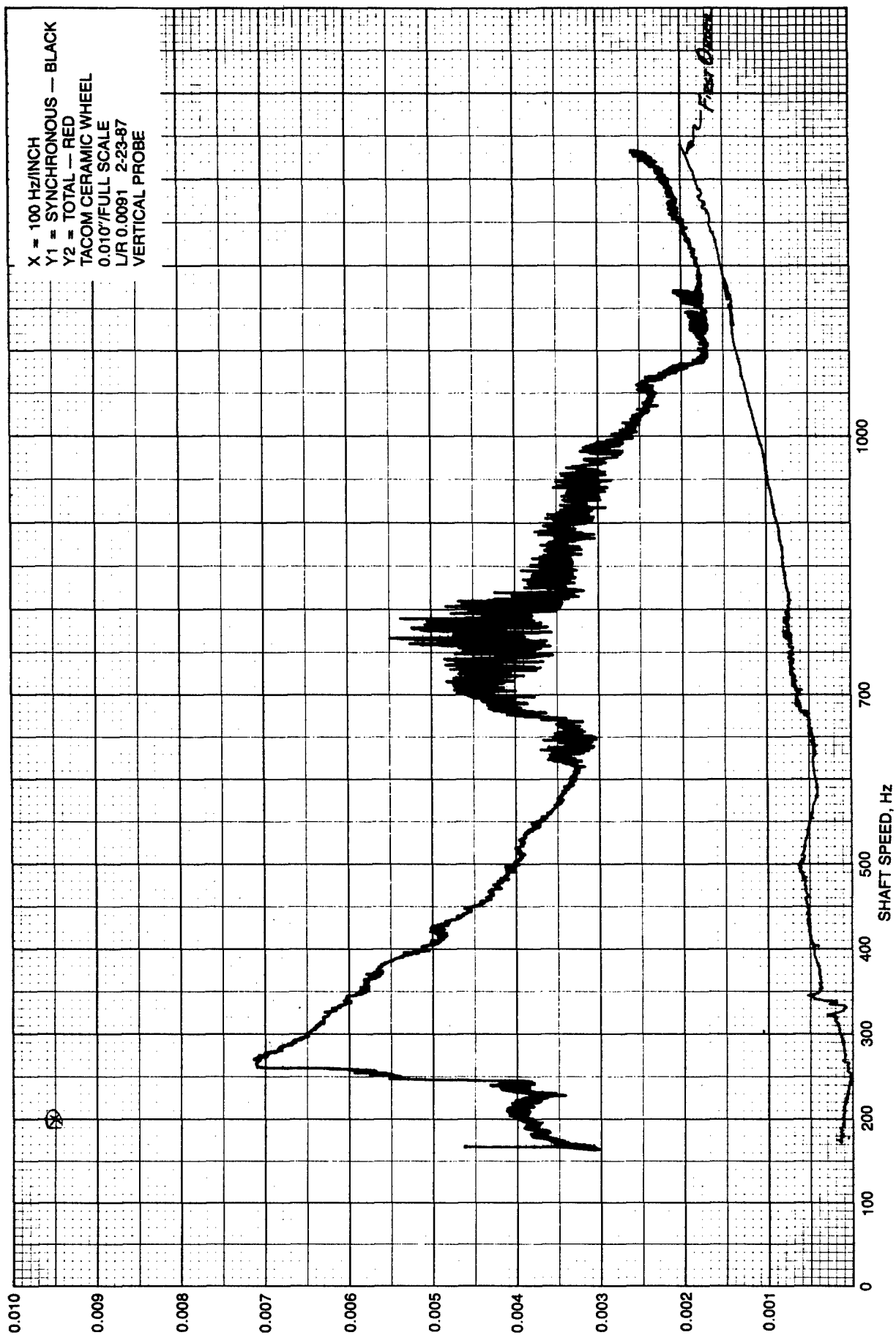
COMMENTS: SHAFT MOTION TEST UNIT AND LATER USED AS DURABILITY TEST UNIT

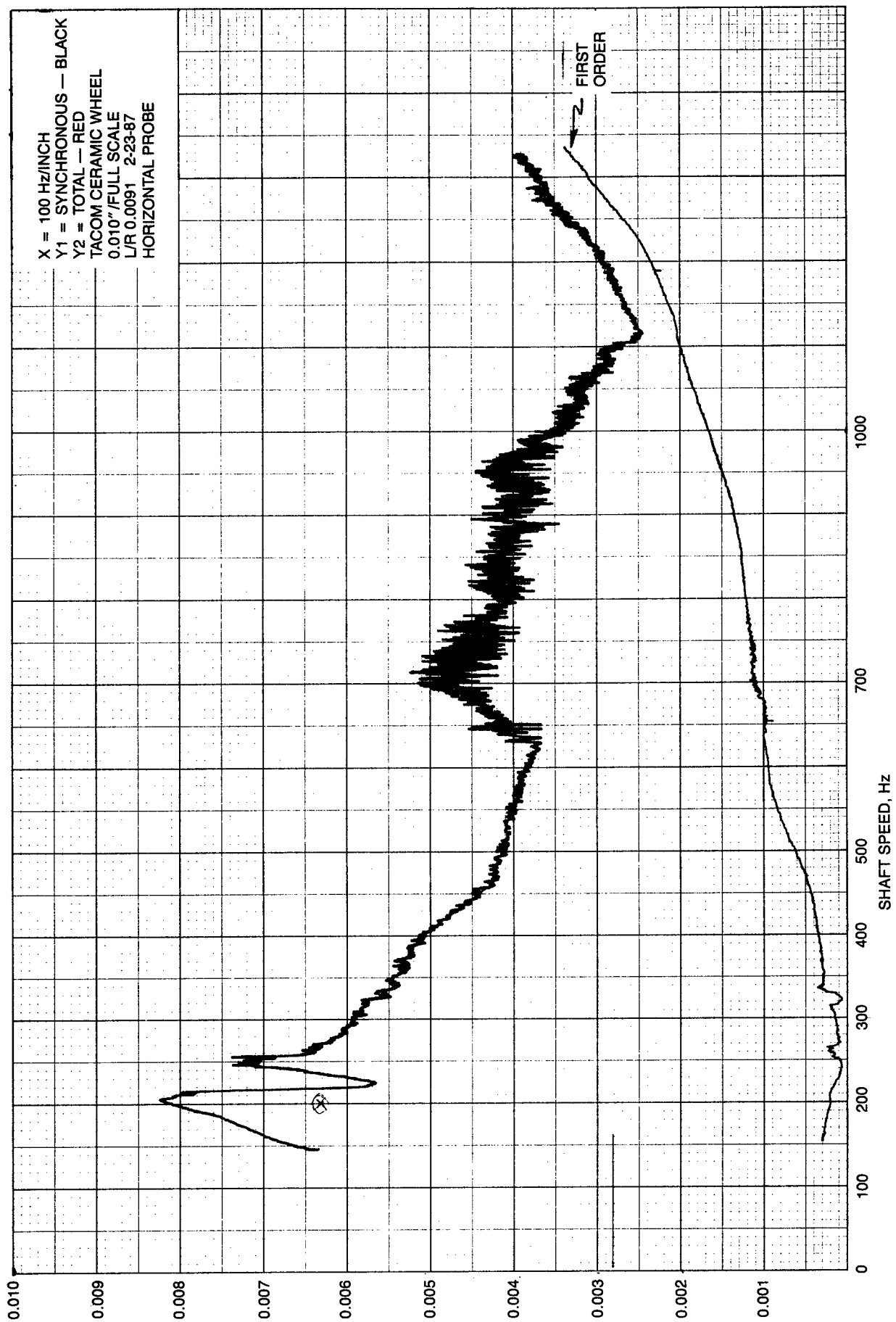


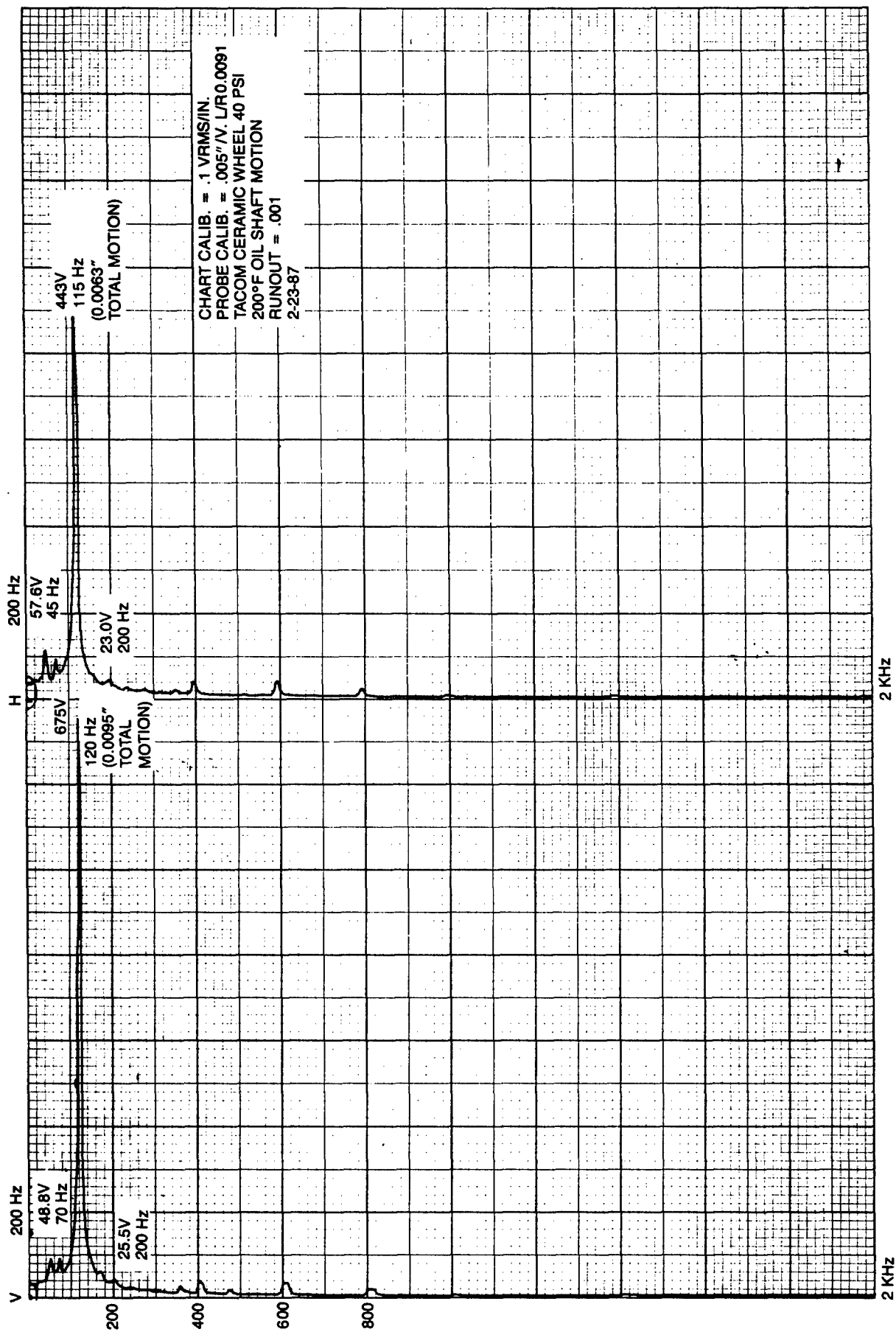


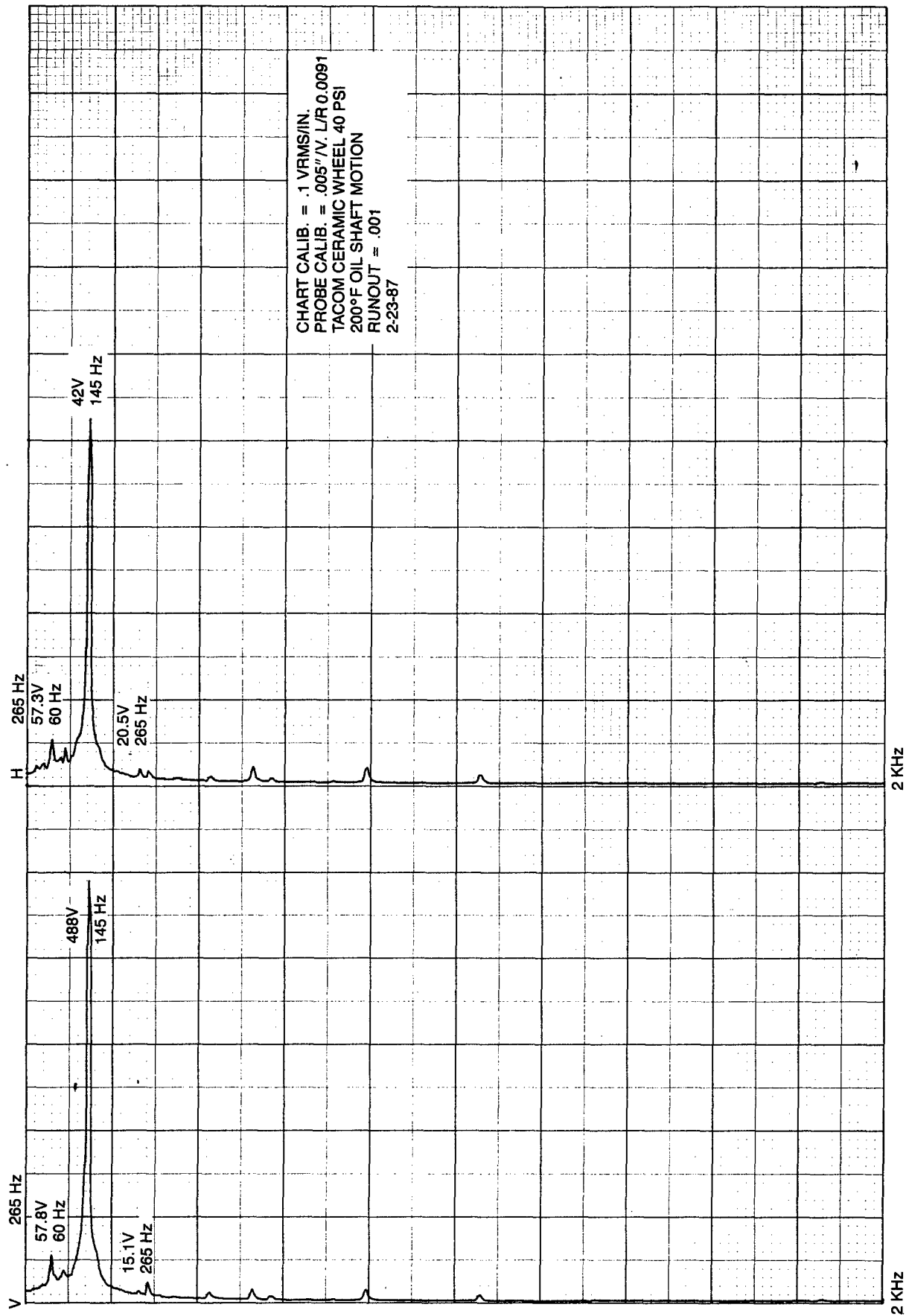
TACOM TV81/CERAMIC WHEEL – SHAFT MOTION – TEST PARAMETERS

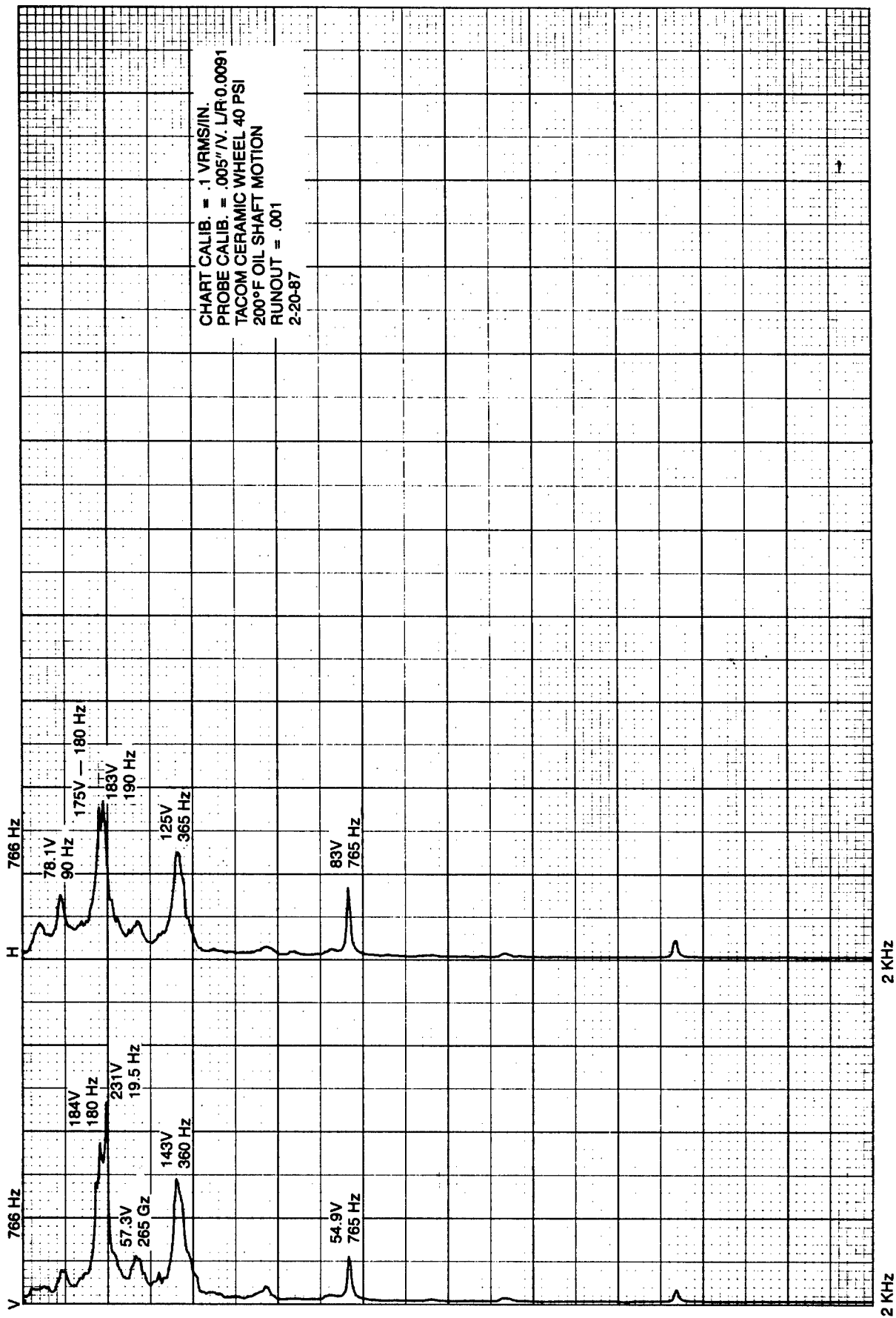
D-7

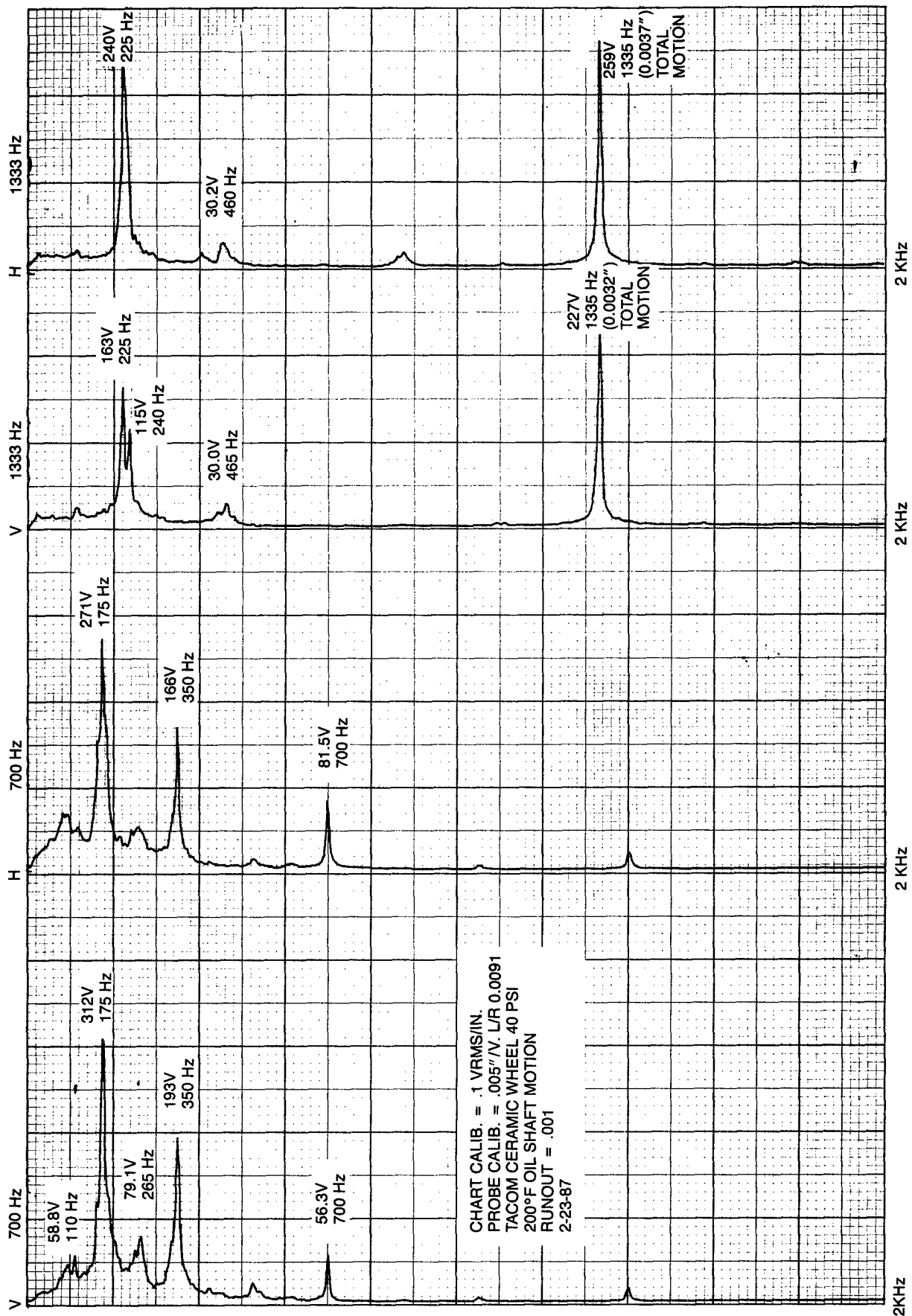












APPENDIX E

TEST DATA – DURABILITY

5.1.5 Durability

Test Procedure:

1. Install test unit on an Arbor Vitae Laboratory bootstrap durability gas stand. Lubricant to be SAE 30 weight engine oil at inlet conditions of 200 F and 40 psig.
2. Start unit and establish minimum operating speed with stable operation.
3. Accelerate unit to 80,000 RPM at a rate of 10,000 RPM per minute. Monitor speed while accelerating. The turbocharger will be operated for two minutes at 80,000 RPM and 1200 F and two minutes at a lower speed and temperature during the 100 hour cyclic endurance test. Total cycle time is estimated to be five minutes giving a total of approximately 1200 cycles for the 100 hour test. Turbine inlet temperature to be 1200 + 50 F at 80,000 RPM.
4. Cycle unit between minimum speed from item 2 and 80,000 RPM with a two minute dwell at each condition. Test for 100 hours. Record operating conditions, number of cycles and test hours every four hours.
5. Remove unit and send to Lomita Development Assembly for teardown inspection.

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TURBO S/N TAC004 CUSTOMER TACOM ENG. _____

CENTER HOUSING

BEARING BORE DIA. (TURB. END) 0.9831/0.9832

BEARING BORE DIA. (COMP. END) 0.98295/0.98295

BEARINGS BRONZE AL OTHER (CIRCLE ONE)

BEARING O.D. (TURB. END) 0.9783/0.9784

BEARING O.D. (COMP. END) 0.97845

BEARING I.D. (TURB. END) 0.7016/.0.7017

BEARING I.D. (COMP. END) 0.62705/0.62715

SHAFT WHEEL ASSEMBLY

TURBINE (END) SIDE JOURNAL DIA. 0.6998

COMP (END) SIDE JOURNAL DIA. 0.6253

C.H.R.A. BEARING CLEARANCES

AT TURBINE BEARING O.D. 0.0047/0.0049

COMP. BEARING O.D. 0.0045

TURBINE BEARING I.D. 0.0018/0.0019

COMP. BEARING I.D. 0.0017⁵/0.0018⁵

SHAFT WHEEL ASSEMBLY END PLAY 0.004

SHAFT WHEEL ASSEMBLY RADIAL PLAY -

IMPELLER CLEARANCE RADIAL 0.016

IMPELLER CLEARANCE TIP 0.020

TURBINE CLEARANCE RADIAL 0.033

TURBINE CLEARANCE TIP 0.025

COMMENTS: _____

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OIL BEARING CERAMIC WHEEL TURBOCHARGER
INSPECTION SHEET

BY

TURBO S/N TAC005 CUSTOMER TACOM ENG. _____CENTER HOUSINGBEARING BORE DIA. (TURB. END) 0.9831/0.98315BEARING BORE DIA. (COMP. END) 0.9830BEARINGS BRONZE AL OTHER (CIRCLE ONE)BEARING O.D. (TURB. END) 0.9784BEARING O.D. (COMP. END) 0.97835/0.9783BEARING I.D. (TURB. END) 0.7017/.0.7016BEARING I.D. (COMP. END) 0.6271SHAFT WHEEL ASSEMBLYTURBINE (END) SIDE JOURNAL DIA. 0.6997/0.6998COMP (END) SIDE JOURNAL DIA. 0.6253C.H.R.A. BEARING CLEARANCESAT TURBINE BEARING O.D. 0.0047/0.0047⁵COMP. BEARING O.D. 0.0046⁵/0.0047TURBINE BEARING I.D. 0.0018/0.0020COMP. BEARING I.D. 0.0018SHAFT WHEEL ASSEMBLY END PLAY 0.004SHAFT WHEEL ASSEMBLY RADIAL PLAY -IMPELLER CLEARANCE RADIAL 0.016IMPELLER CLEARANCE TIP 0.020TURBINE CLEARANCE RADIAL 0.032TURBINE CLEARANCE TIP 0.026

COMMENTS: _____

GARRETT	AIRESEARCH INDUSTRIAL DIVISION LOS ANGELES AND TORRANCE, CALIFORNIA	DATE	PAGE 1 OF 1
	TITLE	NO.	
	OIL BEARING CERAMIC WHEEL TURBOCHARGER INSPECTION SHEET	BY	

TURBO S/N TAC006 CUSTOMER TACOM ENG. _____

CENTER HOUSING

BEARING BORE DIA. (TURB. END) 0.9829

BEARING BORE DIA. (COMP. END) 0.9830

BEARINGS BRONZE AL OTHER (CIRCLE ONE)

BEARING O.D. (TURB. END) 0.9784

BEARING O.D. (COMP. END) 0.9785

BEARING I.D. (TURB. END) 0.7016

BEARING I.D. (COMP. END) 0.6271

SHAFT WHEEL ASSEMBLY

TURBINE (END) SIDE JOURNAL DIA. 0.6998

COMB (END) SIDE JOURNAL DIA. 0.6252

C.H.R.A. BEARING CLEARANCES

AT TURBINE BEARING O.D. 0.0045

COMP. BEARING O.D. 0.0045

TURBINE BEARING I.D. 0.0018

COMP. BEARING I.D. 0.0019

SHAFT WHEEL ASSEMBLY END PLAY 0.004

SHAFT WHEEL ASSEMBLY RADIAL PLAY -

IMPELLER CLEARANCE RADIAL 0.017

IMPELLER CLEARANCE TIP 0.019

TURBINE CLEARANCE RADIAL 0.031

TURBINE CLEARANCE TIP 0.025

COMMENTS: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR S/N TAC005 DATE 3-10-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. FOX DATA SHEET 1 LOG SHEET 1 OF 9

TIME	
	UNIT INSTALLED ON TEST STAND TO BE RUN PER LAB REQUEST 876029
2145	UNIT STARTED FOR OIL WARM UP.
2155	CYCLE STARTED. HOUR METER RESET TO ZERO.
2230	RPM (MIN) 36,900 (MAX) 80,000 PIO = 50.0 PSIG
	TIT (MIN) 1156°F (MAX) TIO = 198°F
	PIT (MIN) 7.9" Hg (MAX) 47.0" Hg
	P2C (MIN) 9.3" Hg (MAX) 53.3" Hg HRS = 0.6
2307	SHUTDOWN TEST-HRS = 1.2.
	3-11-87
1005	UNIT STARTED FOR OIL WARM UP.
1015	CYCLE STARTED.

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR S/N TAC005 DATE 3-11-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. COOPER DATA SHEET 2 LOG SHEET 2 OF 9

TIME					
1210	RPM (MIN)	37,100	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1163°F	(MAX)	1242°F	TIO = 201°F
	PIT (MIN)	7.9" Hg	(MAX)	46.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.7" Hg	HRS = 3.4
1440	RPM (MIN)	36,800	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1169°F	(MAX)	1242°F	TIO = 204°F
	PIT (MIN)	7.9" Hg	(MAX)	46.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.1" Hg	HRS = 5.9
1840	RPM (MIN)	36,900	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1154°F	(MAX)	1237°F	TIO = 202°F
	PIT (MIN)	8.0" Hg	(MAX)	46.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.8" Hg	HRS = 9.9
2245	RPM (MIN)	37,000	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1158°F	(MAX)	1239°F	TIO = 203°F
	PIT (MIN)	8.0" Hg	(MAX)	46.5" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.0" Hg	HRS = 14.0
2310	SHUTDOWN TEST-HRS = 14.4.				

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR S/N TAC005 DATE 3-12-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. COOPER DATA SHEET 3 LOG SHEET 3 OF 9

TIME					
0745	UNIT STARTED FOR OIL WARM UP.				
0755	CYCLE STARTED.				
0905	RPM (MIN)	36,700	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1160°F	(MAX)	1242°F	TIO = 199°F
	PIT (MIN)	7.9" Hg	(MAX)	46.6" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.1" Hg	HRS = 15.8
1335	RPM (MIN)	36,900	(MAX)	79,900	PIO = 50.0 PSIG
	TIT (MIN)	1159°F	(MAX)	1224°F	TIO = 202°F
	PIT (MIN)	7.9" Hg	(MAX)	46.6" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.1" Hg	HRS = 20.3
1720	RPM (MIN)	36,900	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1154°F	(MAX)	1231°F	TIO = 201°F
	PIT (MIN)	7.9" Hg	(MAX)	46.5" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.9" Hg	HRS = 24.0

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR S/N TAC005 DATE 3-12-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. FOX DATA SHEET 4 LOG SHEET 4 OF 9

TIME					
2120	RPM (MIN)	37,000	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1155°F	(MAX)	1222°F	TIO = 199°F
	PIT (MIN)	8.0" Hg	(MAX)	46.5" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.9" Hg	HRS = 28.0
2308	SHUTDOWN TEST-HRS = 29.8.				
	3-13-87				
0745	UNIT STARTED FOR OIL WARM UP.				
0755	TEST CYCLE STARTED.				
0915	RPM (MIN)	36,900	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1158°F	(MAX)	1231°F	TIO = 197°F
	PIT (MIN)	7.9" Hg	(MAX)	46.5" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.8" Hg	HRS = 31.3
1330	RPM (MIN)	36,900	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1160°F	(MAX)	1235°F	TIO = 199°F
	PIT (MIN)	7.8" Hg	(MAX)	46.3" Hg	
	P2C (MIN)	9.2" Hg	(MAX)	52.7" Hg	HRS = 35.5

PAGE TIME: _____

TOTAL TIME: _____

LABORATORY TEST LOG

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR S/N TAC005 DATE 3-13-87

E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029

P/N _____ TECHNICIAN D. FOX DATA SHEET 5 LOG SHEET 5 OF 9

TIME					
1730	RPM (MIN)	39,900	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1154°F	(MAX)	1239°F	TIO = 199°F
	PIT (MIN)	7.9" Hg	(MAX)	46.7" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.9" Hg	HRS = 39.5
2135	RPM (MIN)	39,800	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1156°F	(MAX)	1241°F	TIO = 201°F
	PIT (MIN)	7.9" Hg	(MAX)	46.5" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.7" Hg	HRS = 43.6
2305	SHUTDOWN TEST-HRS = 45.1.				
	3-16-87				
0740	UNIT STARTED FOR OIL WARM UP.				
0750	TEST CYCLE STARTED.				
0920	RPM (MIN)	36,900	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1153°F	(MAX)	1224°F	TIO = 198°F
	PIT (MIN)	7.9" Hg	(MAX)	46.7" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.9" Hg	HRS = 46.8

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR S/N TAC005 DATE 3-16-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. COOPER DATA SHEET 6 LOG SHEET 6 OF 9

TIME					
1330	RPM (MIN)	37,100	(MAX)	79,900	PIO = 50.0 PSIG
	TIT (MIN)	1154°F	(MAX)	1233°F	TIO = 200°F
	PIT (MIN)	7.9" Hg	(MAX)	46.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.7" Hg	HRS = 50.9
1710	RPM (MIN)	37,000	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1152°F	(MAX)	1227°F	TIO = 200°F
	PIT (MIN)	7.9" Hg	(MAX)	46.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.7" Hg	HRS = 54.6
2110	RPM (MIN)	36,900	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1155°F	(MAX)	1226°F	TIO = 199°F
	PIT (MIN)	7.9" Hg	(MAX)	46.4" Hg	
	P2C (MIN)	9.2" Hg	(MAX)	52.7" Hg	HRS = 58.6
2305	SHUTDOWN TEST-HRS = 60.5.				
	3-17-87				
0730	UNIT STARTED FOR OIL WARM UP.				
0740	TEST CYCLE STARTED.				

PAGE TIME: _____

TOTAL TIME: _____

LABORATORY TEST LOG

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR S/N TAC005 DATE 3-17-87

E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029

P/N _____ TECHNICIAN D. COOPER DATA SHEET 7 LOG SHEET 7 OF 9

TIME					
0905	RPM (MIN)	37,000	(MAX)	79,900	PIO = 50.0 PSIG
	TIT (MIN)	1155°F	(MAX)	1235°F	TIO = 198°F
	PIT (MIN)	7.9" Hg	(MAX)	46.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.7" Hg	HRS = 62.1
1425	RPM (MIN)	36,900	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1155°F	(MAX)	1228°F	TIO = 202°F
	PIT (MIN)	7.9" Hg	(MAX)	45.9" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.2" Hg	HRS = 67.4
1820	RPM (MIN)	37,000	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1154°F	(MAX)	1235°F	TIO = 199°F
	PIT (MIN)	7.9" Hg	(MAX)	46.5" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.8" Hg	HRS = 71.3
2220	RPM (MIN)	37,000	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1152°F	(MAX)	1231°F	TIO = 199°F
	PIT (MIN)	7.9" Hg	(MAX)	46.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.7" Hg	HRS = 75.3
2308	SHUTDOWN TEST-HRS = 76.1				

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR S/N TAC005 DATE 3-18-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 8 LOG SHEET 8 OF 9

TIME					
0745	UNIT STARTED FOR OIL WARM UP.				
0755	TEST CYCLE STARTED.				
1155	RPM (MIN)	37,000	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1153°F	(MAX)	1232°F	TIO = 201
	PIT (MIN)	7.9" Hg	(MAX)	45.9" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	45.9" Hg	HRS = 80.3
1615	RPM (MIN)	37,000	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1152°F	(MAX)	1235°F	TIO = 201°F
	PIT (MIN)	7.9" Hg	(MAX)	46.0" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.3" Hg	HRS = 84.6
2115	RPM (MIN)	36,900	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1154°F	(MAX)	1241°F	TIO = 200°F
	PIT (MIN)	8.0" Hg	(MAX)	46.5" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.7" Hg	HRS = 89.6
2310	SHUTDOWN TEST-HRS = 91.5.				

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

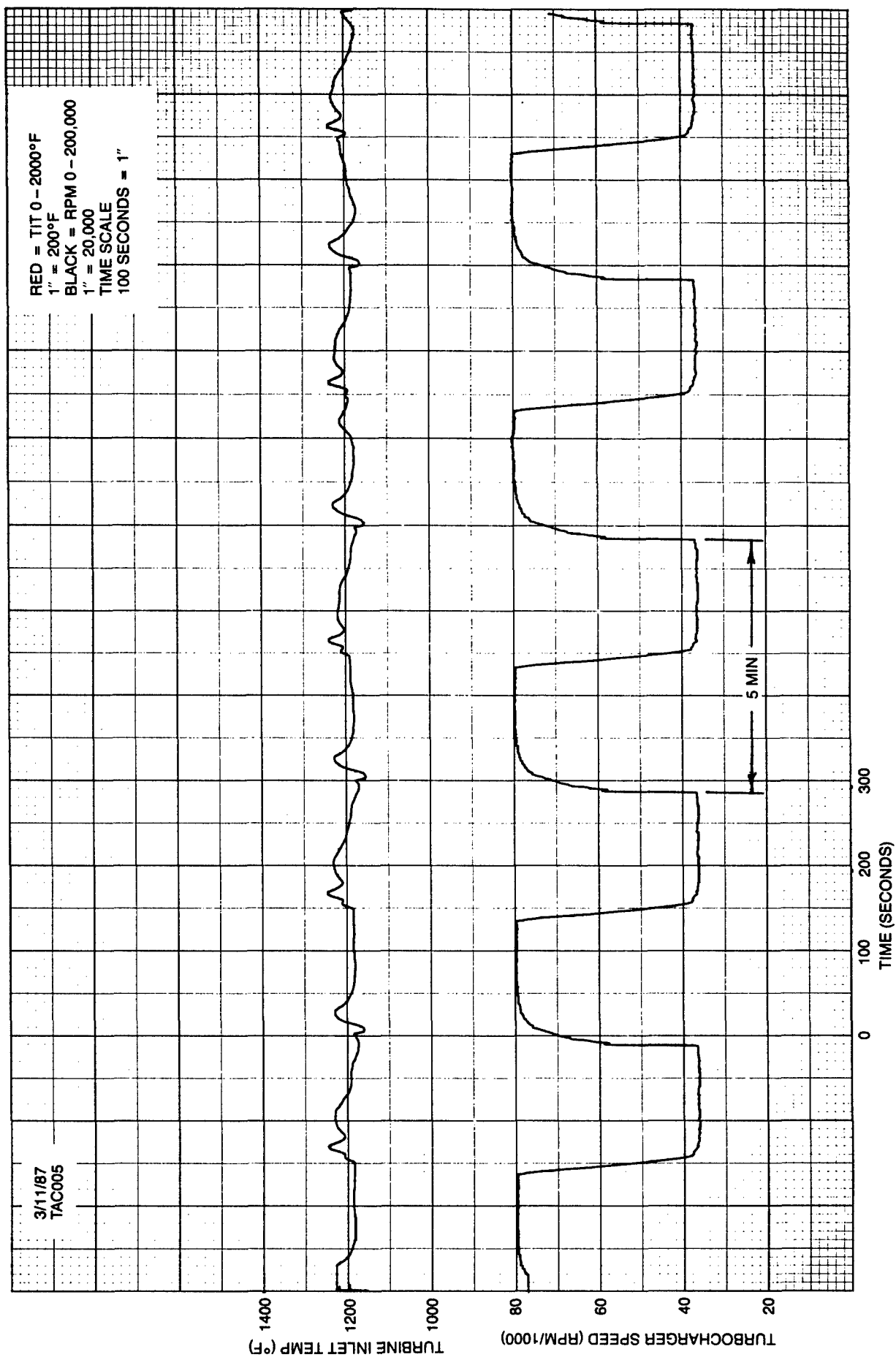
FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR S/N TAC005 DATE 3-19-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 9 LOG SHEET 9 OF 9

TIME	
0735	UNIT STARTED FOR OIL WARM UP.
0745	TEST CYCLE STARTED.
0940	RPM (MIN) 37,000 (MAX) 80,100 PIO = 50.0 PSIG
	TIT (MIN) 1156°F (MAX) 1238°F TIO = 195°F
	PIT (MIN) 7.9" Hg (MAX) 46.3" Hg
	P2C (MIN) 9.3" Hg (MAX) 52.6" Hg HRS = 93.6
1340	RPM (MIN) 37,000 (MAX) 80,100 PIO = 50.0 PSIG
	TIT (MIN) 1156°F (MAX) 1243°F TIO = 198°F
	PIT (MIN) 7.8" Hg (MAX) 46.3" Hg
	P2C (MIN) 9.2" Hg (MAX) 52.6" Hg HRS = 97.6
1605	SHUTDOWN TEST-HRS = 100.0.

PAGE TIME: _____

TOTAL TIME: _____



LABORATORY TEST LOG

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDR CYCLE S/N TAC006 DATE 2-27-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 1 LOG SHEET 1 OF 9

TIME	
	UNIT INSTALLED ON TEST STAND TO RUN PER LAB REQUEST 876029.
1000	UNIT STARTED FOR OIL WARM UP.
1010	TEST CYCLE STARTED. HOUR METER RESET TO ZERO.
1035	RPM (MIN) 36,900 (MAX) 80,300 PIO = 30.0 PSIG
	TIT (MIN) 1151°F (MAX) 1243°F TIO = 194°F
	PIT (MIN) 8.0" Hg (MAX) 48.5" Hg
	P2C (MIN) 9.5" Hg (MAX) 54.7" Hg HRS = 0.5
1405	RPM (MIN) 36,800 (MAX) 80,400 PIO = 50.0 PSIG
	TIT (MIN) 1155°F (MAX) 1244°F TIO = 197°F
	PIT (MIN) 7.9" Hg (MAX) 48.2" Hg
	P2C (MIN) 9.3" Hg (MAX) 54.4" Hg HRS = 4.0
1540	SHUTDOWN = 5.5 HRS.
	3-2-87
0805	UNIT STARTED FOR OIL WARM UP.
0815	TEST CYCLE STARTED.

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDR CYCLE S/N TAC006 DATE 3-2-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 2 LOG SHEET 2 OF 9

TIME					
1000	RPM (MIN)	36,900	(MAX)	80,400	PIO = 50.0 PSIG
	TIT (MIN)	1156°F	(MAX)	1245°F	TIO = 197°F
	PIT (MIN)	7.8" Hg	(MAX)	48.2" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	54.4" Hg	HRS = 7.4
1415	RPM (MIN)	37,000	(MAX)	80,400	PIO = 50.0 PSIG
	TIT (MIN)	1160°F	(MAX)	1246°F	TIO = 198°F
	PIT (MIN)	7.7" Hg	(MAX)	47.8" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.7" Hg	HRS = 11.7
1545	SHUTDOWN-HRS = 13.1.				
	3-3-87				
0745	UNIT STARTED FOR OIL WARM UP.				
0755	TEST CYCLE STARTED.				
0930	RPM (MIN)	36,900	(MAX)	80,400	PIO = 50.0 PSIG
	TIT (MIN)	1155°F	(MAX)	1243°F	TIO = 195°F
	PIT (MIN)	7.7" Hg	(MAX)	48.1" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	54.2" Hg	HRS = 14.8

PAGE TIME: _____

TOTAL TIME: _____

LABORATORY TEST LOG

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDR CYCLE S/N TAC006 DATE 3-3-87

E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029

P/N _____ TECHNICIAN R. STEWART DATA SHEET 3 LOG SHEET 3 OF 9

TIME	
1335	RPM (MIN) 36,900 (MAX) 80,300 PIO = 50.0 PSIG
	TIT (MIN) 1157°F (MAX) 1246°F TIO = 198°F
	PIT (MIN) 7.6" Hg (MAX) 47.6" Hg
	P2C (MIN) 9.3" Hg (MAX) 53.5" Hg HRS = 18.9
1745	RPM (MIN) 36,700 (MAX) 80,200 PIO = 50.0 PSIG
	TIT (MIN) 1160°F (MAX) 1245°F TIO = 199°F
	PIT (MIN) 8.0" Hg (MAX) 47.6" Hg
	P2C (MIN) 9.4" Hg (MAX) 53.7" Hg HRS = 23.1
2145	RPM (MIN) 36,900 (MAX) 80,300 PIO = 50.0 PSIG
	TIT (MIN) 1162°F (MAX) 1247°F TIO = 197°F
	PIT (MIN) 8.0" Hg (MAX) 47.9" Hg
	P2C (MIN) 9.4" Hg (MAX) 54.2" Hg HRS = 27.1
2310	SHUTDOWN TEST-HRS = 28.5.
	3-4-87
0730	UNIT STARTED FOR OIL WARM UP.
0740	TEST CYCLE STARTED.

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDR CYCLE S/N TAC006 DATE 3-4-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 4 LOG SHEET 4 OF 9

TIME					
0955	RPM (MIN)	36,800	(MAX)	80,300	PIO = 50.0 PSIG
	TIT (MIN)	1135°F	(MAX)	1156°F	TIO = 198°F
	PIT (MIN)	7.8" Hg	(MAX)	47.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.6" Hg	HRS = 31.0
1355	RPM (MIN)	36,900	(MAX)	80,300	PIO = 50.0 PSIG
	TIT (MIN)	1162°F	(MAX)	1249°F	TIO = 200°F
	PIT (MIN)	7.7" Hg	(MAX)	47.1" Hg	
	P2C (MIN)	9.2" Hg	(MAX)	53.2" Hg	HRS = 35.0
1745	RPM (MIN)	36,900	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1160°F	(MAX)	1248°F	TIO = 201°F
	PIT (MIN)	7.9" Hg	(MAX)	47.5" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.7" Hg	HRS = 38.8
2140	RPM (MIN)	37,000	(MAX)	80,300	PIO = 50.0 PSIG
	TIT (MIN)		(MAX)	1249°F	TIO = 200°F
	PIT (MIN)	8.0" Hg	(MAX)	47.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.7" Hg	HRS = 42.7
2310	SHUTDOWN TEST-HRS = 44.2.				

PAGE TIME: _____

TOTAL TIME: _____

LABORATORY TEST LOG

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDR CYCLE S/N TAC006 DATE 3-5-87

E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029

P/N _____ TECHNICIAN R. STEWART DATA SHEET 5 LOG SHEET 5 OF 9

TIME	
0745	UNIT STARTED FOR OIL WARM UP.
0755	TEST CYCLE STARTED.
0930	RPM (MIN) 36,700 (MAX) 80,400 PIO = 50.0 PSIG
	TIT (MIN) 1158°F (MAX) 1247°F TIO = 198°F
	PIT (MIN) 7.8" Hg (MAX) 47.4" Hg
	P2C (MIN) 9.3" Hg (MAX) 53.6" Hg HRS = 46.0
1425	RPM (MIN) 36,500 (MAX) 80,100 PIO = 50.0 PSIG
	TIT (MIN) 1161°F (MAX) 1243°F TIO = 200°F
	PIT (MIN) 7.8" Hg (MAX) 47.3" Hg
	P2C (MIN) 9.3" Hg (MAX) 53.5" Hg HRS = 51.0
1810	RPM (MIN) 36,900 (MAX) 80,200 PIO = 50.0 PSIG
	TIT (MIN) 1160°F (MAX) 1248°F TIO = 201°F
	PIT (MIN) 7.9" Hg (MAX) 47.4" Hg
	P2C (MIN) 9.3" Hg (MAX) 53.6" Hg HRS = 54.7

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDR CYCLE S/N TAC006 DATE 3-5-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. FOX DATA SHEET 6 LOG SHEET 6 OF 9

TIME	
2235	RPM (MIN) 36,900 (MAX) 80,200 PIO = 50.0 PSIG
	TIT (MIN) 1156°F (MAX) 1247°F TIO = 202°F
	PIT (MIN) 7.9" Hg (MAX) 47.6" Hg
	P2C (MIN) 9.3" Hg (MAX) 53.8" Hg HRS = 59.1
2305	SHUTDOWN TEST-HRS = 59.6
	3-6-87
0750	UNIT STARTED FOR OIL WARM UP.
0800	CYCLE STARTED.
0925	RPM (MIN) 36,800 (MAX) 80,300 PIO = 50.0 PSIG
	TIT (MIN) 1155°F (MAX) 1248°F TIO = 198°F
	PIT (MIN) 7.7" Hg (MAX) 47.4" Hg
	P2C (MIN) 9.3" Hg (MAX) 53.7" Hg HRS = 61.5
1325	RPM (MIN) 36,900 (MAX) 80,300 PIO = 50.0 PSIG
	TIT (MIN) 1159°F (MAX) 1245°F TIO = 200°F
	PIT (MIN) 7.8" Hg (MAX) 47.3" Hg
	P2C (MIN) 9.3" Hg (MAX) 53.5" Hg HRS = 65.5

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDR CYCLE S/N TAC006 DATE 3-6-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. FOX DATA SHEET 7 LOG SHEET 7 OF 9

TIME					
1745	RPM (MIN)	36,500	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1159°F	(MAX)	1249°F	TIO = 201°F
	PIT (MIN)	7.7" Hg	(MAX)	47.5" Hg	
	P2C (MIN)	9.1" Hg	(MAX)	53.7" Hg	HRS = 69.8
2140	RPM (MIN)	36,500	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1157°F	(MAX)	1248°F	TIO = 200°F
	PIT (MIN)	7.7" Hg	(MAX)	47.5" Hg	
	P2C (MIN)	9.1" Hg	(MAX)	53.7" Hg	HRS = 73.7
2310	SHUTDOWN TEST-HRS = 75.2				
	3-9-87				
0745	UNIT STARTED FOR OIL WARM UP.				
0755	TEST CYCLE STARTED.				
0855	RPM (MIN)	36,400	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1161°F	(MAX)	1246°F	TIO = 198°F
	PIT (MIN)	7.7" Hg	(MAX)	47.4" Hg	
	P2C (MIN)	9.1" Hg	(MAX)	53.4" Hg	HRS = 76.4

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDR CYCLE S/N TAC006 DATE 3-9-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. COOPER DATA SHEET 8 LOG SHEET 8 OF 9

TIME					
1355	RPM (MIN)	36,500	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1178°F	(MAX)	1232°F	TIO = 200°F
	PIT (MIN)	7.7" Hg	(MAX)	47.5" Hg	
	P2C (MIN)	9.1" Hg	(MAX)	53.7" Hg	HRS = 81.4
1720	RPM (MIN)	36,900	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1160°F	(MAX)	1246°F	TIO = 199°F
	PIT (MIN)	7.9" Hg	(MAX)	47.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.5" Hg	HRS = 84.8
2150	RPM (MIN)	36,800	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1166°F	(MAX)	1248°F	TIO = 198°F
	PIT (MIN)	7.9" Hg	(MAX)	47.2" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.4" Hg	HRS = 89.3
2308	SHUTDOWN TEST-HRS = 90.6				
	3-10-87				
0740	UNIT STARTED FOR OIL WARM UP.				
0750	TEST CYCLE STARTED.				

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDR CYCLE S/N TAC006 DATE 3-10-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 9 LOG SHEET 9 OF 9

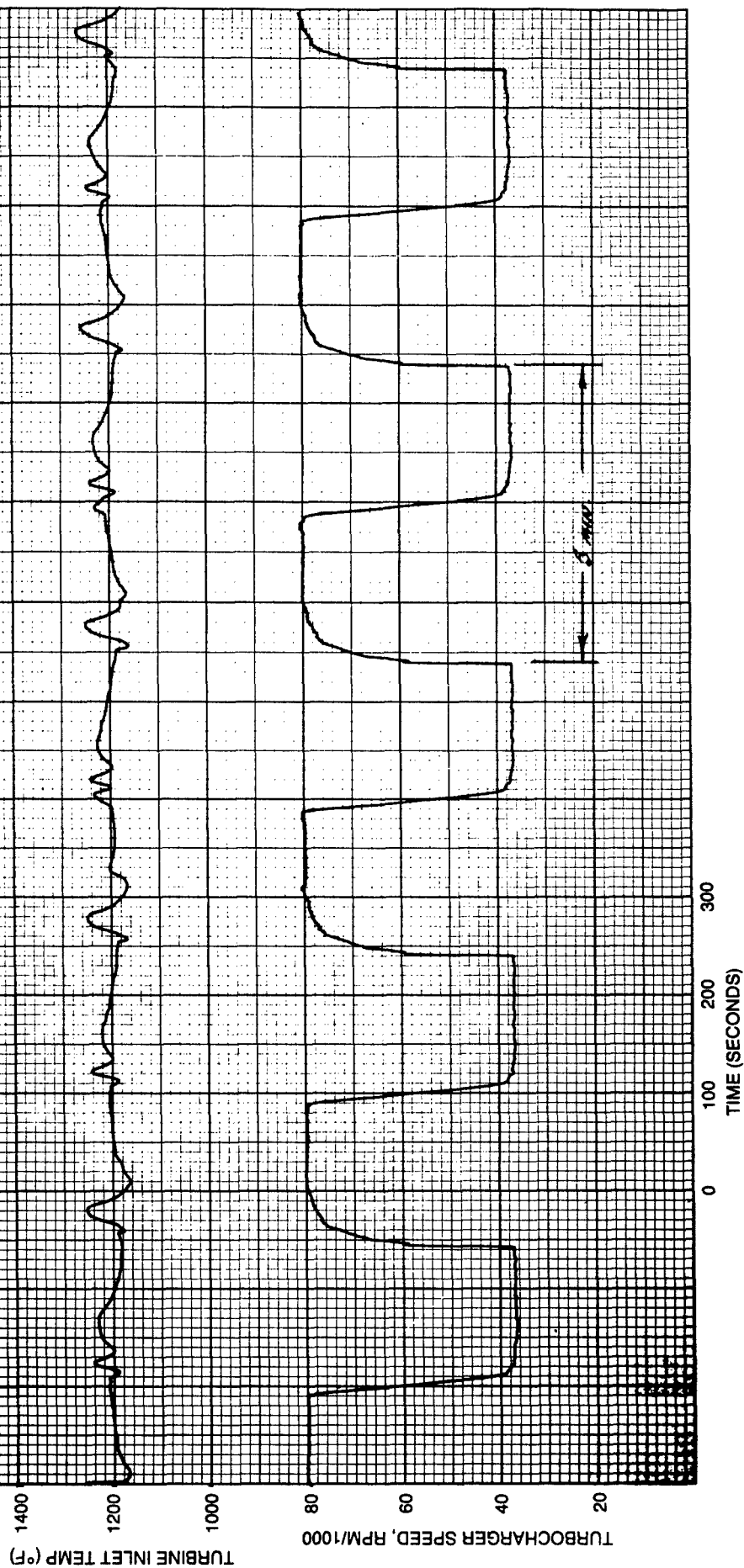
TIME					
0945	RPM (MIN)	36,900	(MAX)	80,300	PIO = 50.0 PSIG
	TIT (MIN)	1158°F	(MAX)	1243°F	TIO = 198°F
	PIT (MIN)	7.8" Hg	(MAX)	47.5" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.6" Hg	HRS = 92.7
1340	RPM (MIN)	36,800	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1170°F	(MAX)	1249°F	TIO = 201°F
	PIT (MIN)	7.8" Hg	(MAX)	47.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.6" Hg	HRS = 96.6
1640	RPM (MIN)	36,900	(MAX)	80,000	PIO = 50.0 PSIG
	TIT (MIN)	1165°F	(MAX)	1247°F	TIO = 199°F
	PIT (MIN)	7.9" Hg	(MAX)	47.2" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.4" Hg	HRS = 99.6
1705	SHUTDOWN TEST-HRS = 100.0				

PAGE TIME: _____

TOTAL TIME: _____

2/27/87
S/W TAC006

RED = TIT 0 - 2000°F
1" = 200°F
BLACK = RPM 0 - 200,000
1" = 20,000
TIME SCALE —
100 SECONDS = 1"



GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR S/N TAC008 DATE 3-23-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. COOPER DATA SHEET 1 LOG SHEET 1 OF 9

TIME	
	UNIT INSTALLED ON TEST STAND TO BE RUN PER LAB REQUEST 876029.
1235	UNIT STARTED FOR OIL WARM UP.
1245	CYCLE STARTED HOUR METER REST TO ZERO.
1610	RPM (MIN) 37,000 (MAX) 80,000 PIO = 50.0 PSIG
	TIT (MIN) 1153°F (MAX) 1227°F TIO = 198°F
	PIT (MIN) 8.1" Hg (MAX) 46.7" Hg
	P2C (MIN) 9.4" Hg (MAX) 52.9" Hg HRS = 3.4
2035	RPM (MIN) 37,000 (MAX) 80,100 PIO = 50.0 PSIG
	TIT (MIN) 1158°F (MAX) 1230°F TIO = 197°F
	PIT (MIN) 8.1" Hg (MAX) 46.7" Hg
	P2C (MIN) 9.4" Hg (MAX) 52.9" Hg HRS = 7.8
2310	SHUTDOWN TEST-HRS = 10.4
	3-24-87
0740	UNIT STARTED FOR OIL WARM UP.

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC TURB WHL S/N TAC008 DATE 3-24-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 2 LOG SHEET 2 OF 9

TIME					
0750	TEST CYCLE STARTED.				
0915	RPM (MIN)	36,900	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1159°F	(MAX)	1226°F	TIO = 199°F
	PIT (MIN)	8.1" Hg	(MAX)	46.6" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	52.6" Hg	HRS = 12.0
1325	RPM (MIN)	37,100	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1154°F	(MAX)	1231°F	TIO = 202°F
	PIT (MIN)	8.1" Hg	(MAX)	46.5" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	52.6" Hg	HRS = 16.2
1735	RPM (MIN)	37,000	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1157°F	(MAX)	1224°F	TIO = 201°F
	PIT (MIN)	8.0" Hg	(MAX)	46.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.5" Hg	HRS = 20.3
2130	RPM (MIN)	37,100	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1153°F	(MAX)	1225°F	TIO = 201°F
	PIT (MIN)	8.1" Hg	(MAX)	46.7" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	52.9" Hg	HRS = 24.2

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC TURB WHEEL S/N TAC008 DATE 3-24-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. FOX DATA SHEET 3 LOG SHEET 3 OF 9

TIME	
2305	SHUTDOWN TEST-HRS = 25.8
	3-25-87
0735	UNIT STARTED FOR OIL WARM UP.
0745	TEST CYCLE STARTED.
0900	RPM (MIN) 36,800 (MAX) 80,200 PIO = 50.0 PSIG
	TIT (MIN) 1169°F (MAX) 1231°F TIO = 202°F
	PIT (MIN) 8.0" Hg (MAX) 46.4" Hg
	P2C (MIN) 9.3" Hg (MAX) 52.5" Hg HRS = 27.2
0930	SHUT UNIT DOWN FOR PHOTOGRAPHYS HRS 27.7.
0940	TEST RESTARTED.
1325	RPM (MIN) 37,100 (MAX) 80,100 PIO = 50.0 PSIG
	TIT (MIN) 1170°F (MAX) 1245°F TIO = 204°F
	PIT (MIN) 8.0" Hg (MAX) 46.4" Hg
	P2C (MIN) 9.3" Hg (MAX) 52.5" Hg HRS = 31.7

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC TURB WHEEL S/N TAC008 DATE 3-25-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. FOX DATA SHEET 4 LOG SHEET 4 OF 9

TIME					
1755	RPM (MIN)	37,000	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1157°F	(MAX)	1231°F	TIO = 204°F
	PIT (MIN)	8.0" Hg	(MAX)	46.4" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.6" Hg	HRS = 36.1
2200	RPM (MIN)	37,100	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1155°F	(MAX)	1229°F	TIO = 201°F
	PIT (MIN)	8.1" Hg	(MAX)	46.6" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	52.8" Hg	HRS = 40.2
2308	SHUTDOWN TEST-HRS = 41.3				
	3-26-87				
0745	UNIT STARTED FOR OIL WARM UP.				
0755	TEST CYCLE STARTED.				
0910	RPM (MIN)	36,900	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1172°F	(MAX)	1244°F	TIO = 203°F
	PIT (MIN)	8.1" Hg	(MAX)	46.6" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	52.8" Hg	HRS = 42.8

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC TURB WHEEL S/N TAC008 DATE 3-26-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. COOPER DATA SHEET 5 LOG SHEET 5 OF 9

TIME					
1420	RPM (MIN)	36,900	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1172°F	(MAX)	1233°F	TIO = 199°F
	PIT (MIN)	7.9" Hg	(MAX)	46.4" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	52.4" Hg	HRS = 47.9
1845	RPM (MIN)	37,000	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1156°F	(MAX)	1228°F	TIO = 203°F
	PIT (MIN)	8.1" Hg	(MAX)	46.5" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	52.7" Hg	HRS = 52.3
2245	RPM (MIN)	37,000	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1153°F	(MAX)	1239°F	TIO = 200°F
	PIT (MIN)	8.1" Hg	(MAX)	46.7" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	52.9" Hg	HRS = 56.3
2310	SHUTDOWN TEST-HRS = 56.7				
	3-27-87				
0745	UNIT STARTED FOR OIL WARM UP.				
0755	TEST CYCLE STARTED.				

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC TURB WHL S/N TAC008 DATE 3-27-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 6 LOG SHEET 6 OF 9

TIME					
0915	RPM (MIN)	37,000	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1155°F	(MAX)	1240°F	TIO = 199°F
	PIT (MIN)	7.9" Hg	(MAX)	46.7" Hg	
	P2C (MIN)	9.2" Hg	(MAX)	52.8" Hg	HRS = 58.2
1335	RPM (MIN)	37,100	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1153°F	(MAX)	1239°F	TIO = 200°F
	PIT (MIN)	7.9" Hg	(MAX)	46.3" Hg	
	P2C (MIN)	9.2" Hg	(MAX)	52.3" Hg	HRS = 62.5
1755	RPM (MIN)	37,000	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1164°F	(MAX)	1223°F	TIO = 203°F
	PIT (MIN)	7.9" Hg	(MAX)	46.5" Hg	
	P2C (MIN)	9.2" Hg	(MAX)	52.7" Hg	HRS = 66.9
2120	RPM (MIN)	37,000	(MAX)	80,100	P10 = 50.0 PSIG
	TIT (MIN)	1155°F	(MAX)		TIO =
	PIT (MIN)	8.0" Hg	(MAX)	46.7" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	52.9" Hg	HRS = 70.3
2307	SHUTDOWN TEST-HRS = 72.1.				

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC TURB WHL S/N TAC008 DATE 3-30-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 7 LOG SHEET 7 OF 9

TIME	
0740	UNIT STARTED FOR OIL WARM UP.
0750	TEST CYCLE STARTED.
0900	RPM (MIN) 37,000 (MAX) 80,100 PIO = 50.0 PSIG
	TIT (MIN) 1153°F (MAX) 1235°F TIO = 201°F
	PIT (MIN) 7.8" Hg (MAX) 46.5" Hg
	P2C (MIN) 9.2" Hg (MAX) 52.7" Hg HRS = 73.4
1405	RPM (MIN) 37,100 (MAX) 80,000 PIO = 50.0 PSIG
	TIT (MIN) 1153°F (MAX) 1229°F TIO = 201°F
	PIT (MIN) 7.8" Hg (MAX) 46.5" Hg
	P2C (MIN) 9.2" Hg (MAX) 52.7" Hg HRS = 78.6
1845	RPM (MIN) 37,000 (MAX) 80,100 PIO = 50.0 PSIG
	TIT (MIN) 1151°F (MAX) 1238°F TIO = 203°F
	PIT (MIN) 7.9" Hg (MAX) 46.7" Hg
	P2C (MIN) 9.3" Hg (MAX) 52.9" Hg HRS = 83.2

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC TURB WHEEL S/N TAC008 DATE 3-30-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. FOX DATA SHEET 8 LOG SHEET 8 OF 9

TIME					
2215	RPM (MIN)	37,100	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1154°F	(MAX)	1243°F	TIO = 204°F
	PIT (MIN)	8.0" Hg	(MAX)	46.8" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.0" Hg	HRS = 86.7
2310	SHUTDOWN TEST-HRS = 87.6.				
	3-31-87				
0740	UNIT STARTED FOR OIL WARM UP.				
0750	TEST CYCLE STARTED.				
0925	RPM (MIN)	37,000	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1155°F	(MAX)	1245°F	TIO = 204°F
	PIT (MIN)	7.8" Hg	(MAX)	46.2" Hg	
	P2C (MIN)	9.2" Hg	(MAX)	52.2" Hg	HRS = 89.4
1355	RPM (MIN)	36,900	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1161°F	(MAX)	1246°F	TIO = 198°F
	PIT (MIN)	7.7" Hg	(MAX)	46.1" Hg	
	P2C (MIN)	9.1" Hg	(MAX)	52.1" Hg	HRS = 93.9

PAGE TIME: _____

TOTAL TIME: _____

GARRETT

LABORATORY TEST LOG

FORM 2880 R

FORM 2880 R
ARTICLE ON TEST TV81 CERAMIC TURB WHEEL S/N TAC008 DATE 3-31-87

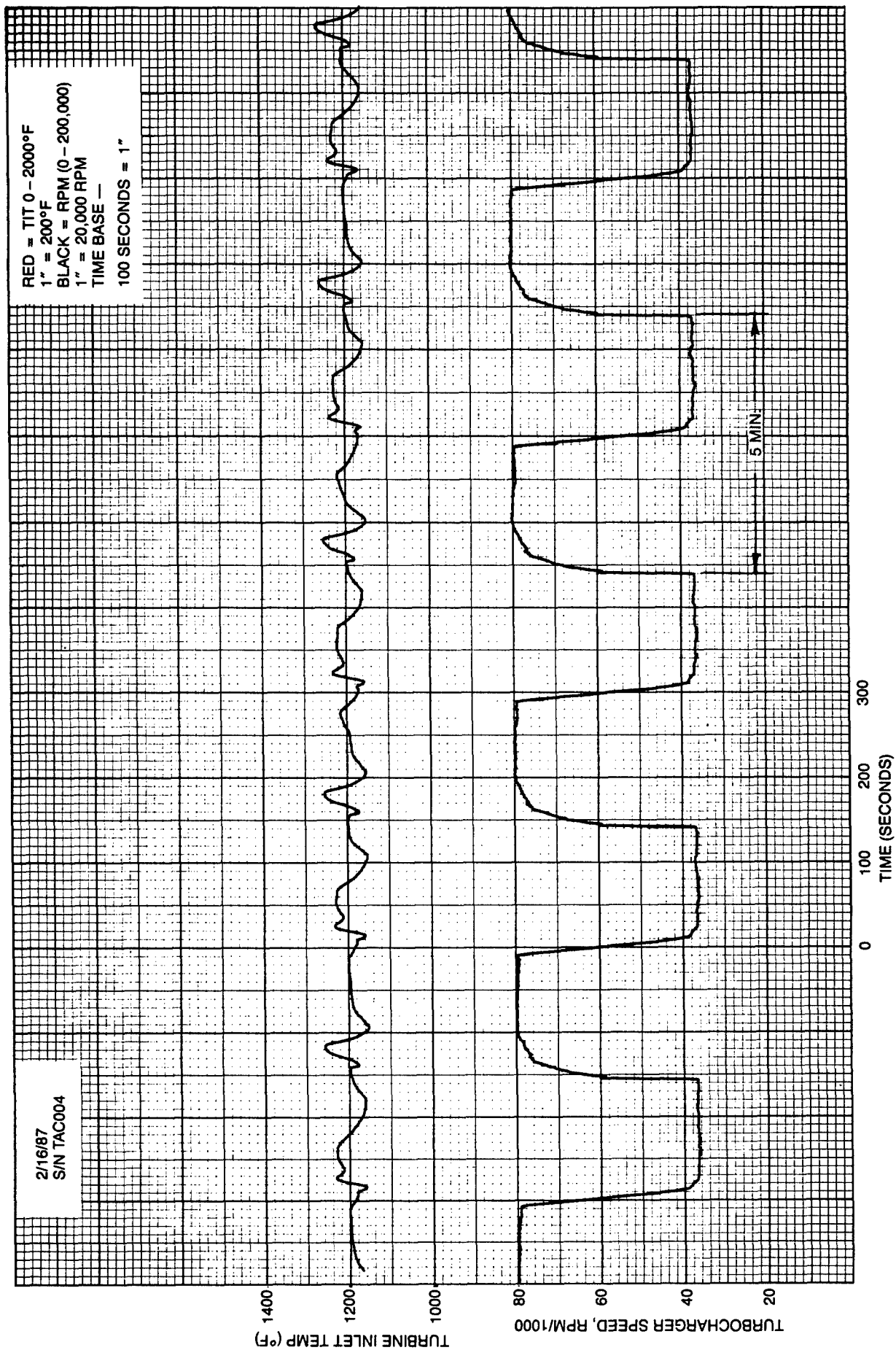
E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029

P/N _____ TECHNICIAN D. FOX DATA SHEET 9 LOG SHEET 9 OF 9

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PAGE TIME: _____

TOTAL TIME: _____



GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR CYCLE S/N TAC004 DATE 2-16-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 1 LOG SHEET 1 OF 9

TIME	
	INSTALLED UNIT ON TEST STAND FOR TEST PER LAB REQUEST 876029.
	(NOTE) NEW 30 WT. OIL AND OIL FILTER WAS PUT INTO OIL STAND.
1035	UNIT STARTED FOR OIL WARM UP
1045	TEST CYCLE STARTED. HOUR METER RESET TO ZERO.
1345	RPM (MIN) 37,100 (MAX) 80,100 PIO = 50.0 PSIG
	TIT (MIN) 1153°F (MAX) 1250°F TIO = 197°F
	PIT (MIN) 7.8" Hg (MAX) 46.4" Hg
	P2C (MIN) 9.2" Hg (MAX) 32.4" Hg HRS = 3.0
1755	RPM (MIN) 36,900 (MAX) 80,100 PIO = 50.0 PSIG
	TIT (MIN) 1157°F (MAX) 1250°F TIO = 199°F
	PIT (MIN) 7.7" Hg (MAX) 46.6" Hg
	P2C (MIN) 9.2" Hg (MAX) 52.7" Hg HRS = 7.2

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR CYCLE S/N TAC004 DATE 2-16-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. FOX DATA SHEET 2 LOG SHEET 2 OF 9

TIME					
2125	RPM (MIN)	36,500	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1162°F	(MAX)	1249°F	TIO = 196°F
	PIT (MIN)	7.7" Hg	(MAX)	47.4" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	53.5" Hg	HRS = 10.7
2307	SHUTDOWN TEST-HRS = 12.4				
	2-17-87				
0735	UNIT STARTED FOR OIL WARM UP.				
0745	TEST CYCLE STARTED.				
0915	RPM (MIN)	36,800	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1163°F	(MAX)	1245°F	TIO = 195°F
	PIT (MIN)	7.8" Hg	(MAX)	47.0" Hg	
	P2C (MIN)	9.2" Hg	(MAX)	53.0" Hg	HRS = 14.1
1350	RPM (MIN)	36,900	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1160°F	(MAX)	1243°F	TIO = 201°F
	PIT (MIN)	7.7" Hg	(MAX)	47.1" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	53.3" Hg	HRS = 18.7

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR CYCLE S/N TAC004 DATE 2-17-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. FOX DATA SHEET 3 LOG SHEET 3 OF 9

TIME					
1720	RPM (MIN)	36,600	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1162°F	(MAX)	1248°F	TIO = 198°F
	PIT (MIN)	7.8" Hg	(MAX)	47.2" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.3" Hg	HRS = 22.2
2130	RPM (MIN)	36,500	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1161°F	(MAX)	1249°F	TIO = 199°F
	PIT (MIN)	7.7" Hg	(MAX)	47.4" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	53.5" Hg	HRS = 26.4
2308	SHUTDOWN TEST-HRS = 28.0				
	2-18-87				
0730	UNIT STARTED FOR OIL WARM UP.				
0740	TEST CYCLE STARTED.				
0900	RPM (MIN)	36,600	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1163°F	(MAX)	1247°F	TIO = 196°F
	PIT (MIN)	7.8" Hg	(MAX)	47.2" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.2" Hg	HRS = 29.5

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR CYCLE S/N TAC004 DATE 2-18-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 4 LOG SHEET 4 OF 9

TIME					
1335	RPM (MIN)	36,800	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1165°F	(MAX)	1246°F	TIO = 199°F
	PIT (MIN)	7.9" Hg	(MAX)	47.0" Hg	
	P2C (MIN)	9.5" Hg	(MAX)	53.0" Hg	HRS = 34.0
1720	RPM (MIN)	36,500	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1158°F	(MAX)	1249°F	TIO = 197°F
	PIT (MIN)	7.7" Hg	(MAX)	47.0" Hg	
	P2C (MIN)	9.2" Hg	(MAX)	53.1" Hg	HRS = 37.8
2115	RPM (MIN)	36,900	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1161°F	(MAX)	1250°F	TIO = 198°F
	PIT (MIN)	7.9" Hg	(MAX)	47.1" Hg	
	P2C (MIN)	9.5" Hg	(MAX)	53.2" Hg	HRS = 41.7
2308	SHUTDOWN TEST-HRS = 43.6				
	2-19-87				
0735	UNIT STARTED FOR OIL WARM UP.				
0745	TEST CYCLE STARTED.				

PAGE TIME: _____

TOTAL TIME: _____

LABORATORY TEST LOG

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR CYCLE S/N TAC004 DATE 2-19-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 5 LOG SHEET 5 OF 9

TIME					
1350	RPM (MIN)	36,800	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1163°F	(MAX)	1245°F	TIO = 198°F
	PIT (MIN)	7.9" Hg	(MAX)	46.5" Hg	
	P2C (MIN)	9.5" Hg	(MAX)	52.5" Hg	HRS = 49.8
1755	RPM (MIN)	36,500	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1159°F	(MAX)	1248°F	TIO = 197°F
	PIT (MIN)	7.7" Hg	(MAX)	47.3" Hg	
	P2C (MIN)	9.2" Hg	(MAX)	53.4" Hg	HRS = 53.9
2130	RPM (MIN)	36,300	(MAX)	80,100	PIO = 50.0 PSIG
	TIT (MIN)	1160°F	(MAX)	1246°F	TIO = 195°F
	PIT (MIN)	7.6" Hg	(MAX)	47.5" Hg	
	P2C (MIN)	9.1" Hg	(MAX)	53.6" Hg	HRS = 57.5
2307	SHUTDOWN TEST-HRS = 59.1				
	2-20-87				
0735	UNIT STARTED FOR OIL WARM UP.				
0745	TEST CYCLE STARTED.				

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR CYCLE S/N TAC004 DATE 2-20-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 6 LOG SHEET 6 OF 9

TIME					
0910	RPM (MIN)	36,700	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1160°F	(MAX)	1247°F	TIO = 195°F
	PIT (MIN)	7.7" Hg	(MAX)	47.5" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.5" Hg	HRS = 60.7
1340	RPM (MIN)	36,800	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1163°F	(MAX)	1245°F	TIO = 197°F
	PIT (MIN)	7.7" Hg	(MAX)	47.2" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.2" Hg	HRS = 65.2
1730	RPM (MIN)	36,600	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1161°F	(MAX)	1248°F	TIO = 197°F
	PIT (MIN)	7.7" Hg	(MAX)	47.5" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.6" Hg	HRS = 69.0
2130	RPM (MIN)	36,400	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1160°F	(MAX)	1246°F	TIO = 196°F
	PIT (MIN)	7.6" Hg	(MAX)	47.5" Hg	
	P2C (MIN)	9.2" Hg	(MAX)	53.6" Hg	HRS = 73.0
2300	SHUTDOWN TEST-HRS = 74.5				

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR CYCLE S/N TAC004 DATE 2-23-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 7 LOG SHEET 7 OF 9

TIME	
0745	UNIT STARTED FOR OIL WARM UP.
0755	TEST CYCLE STARTED.
1005	RPM (MIN) 36,800 (MAX) 80,300 PIO = 50.0 PSIG
	TIT (MIN) 1160°F (MAX) 1243°F TIO = 195°F
	PIT (MIN) 7.7" Hg (MAX) 47.3" Hg
	P2C (MIN) 9.3" Hg (MAX) 53.3" Hg HRS = 76.8
1340	RPM (MIN) 36,700 (MAX) 80,200 PIO = 50.0 PSIG
	TIT (MIN) 1158°F (MAX) 1246°F TIO = 195°F
	PIT (MIN) 7.6" Hg (MAX) 47.1" Hg
	P2C (MIN) 9.3" Hg (MAX) 53.1" Hg HRS = 80.4
1545	SHUTDOWN FOR NIGHT = 82.5 HRS.
	2-24-87
0740	UNIT STARTED FOR OIL WARM UP.
0750	TEST CYCLE STARTED.

PAGE TIME: _____

TOTAL TIME: _____

GARRETT**LABORATORY TEST LOG**

FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR CYCLE S/N TAC004 DATE 2-24-87E.W.O/CHGE. NO. 3310-95-790 SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN R. STEWART DATA SHEET 8 LOG SHEET 8 OF 9

TIME					
0920	RPM (MIN)	36,700	(MAX)	80,200	PIO = 50.0 PSIG
	TIT (MIN)	1161°F	(MAX)	1248°F	TIO = 195°F
	PIT (MIN)	7.8" Hg	(MAX)	47.6" Hg	
	P2C (MIN)	9.4" Hg	(MAX)	53.6" Hg	HRS = 84.1
1520	RPM (MIN)	37,200	(MAX)	80,300	PIO = 50.0 PSIG
	TIT (MIN)	1185°F	(MAX)	1255°F	TIO = 192°F
	PIT (MIN)	8.1" Hg	(MAX)	47.7" Hg	
	P2C (MIN)	9.7" Hg	(MAX)	53.7" Hg	HRS = 90.1
1545	SHUTDOWN. 90.5 HRS.				
	2-25-87				
0810	UNIT STARTED FOR OIL WARMUP.				
0820	CYCLE STARTED				
0925	RPM (MIN)	36,800	(MAX)	80,300	PIO = 50.0 PSIG
	TIT (MIN)	1158°F	(MAX)	1246°F	TIO = 195°F
	PIT (MIN)	7.8" Hg	(MAX)	47.7" Hg	
	P2C (MIN)	9.3" Hg	(MAX)	53.7" Hg	HRS = 91.9

PAGE TIME: _____

TOTAL TIME: _____

LABORATORY TEST LOG

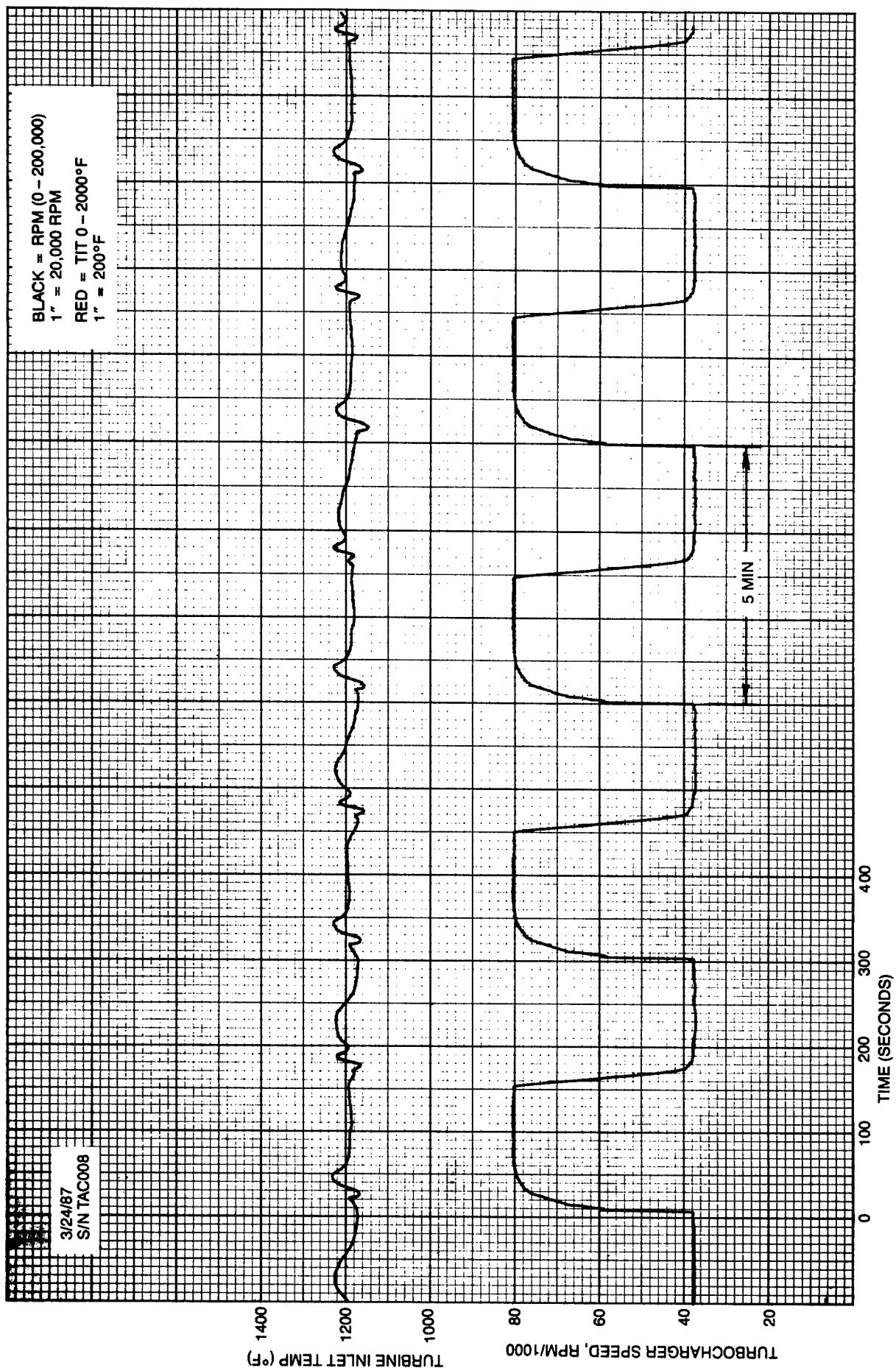
FORM 2880 R

ARTICLE ON TEST TV81 CERAMIC WHL ENDUR CYCLE S/N TAC004 DATE 2-25-87E.W.O/CHGE. NO. _____ SUPP. B. MULLEN I.D. 876029P/N _____ TECHNICIAN D. COOPER DATA SHEET 9 LOG SHEET 9 OF 9

TIME	
1355	RPM (MIN) 37,400 (MAX) 80,200 PIO = 50.0 PSIG
	TIT (MIN) 1181°F (MAX) 1244°F TIO = 193°F
	PIT (MIN) 7.9" Hg (MAX) 47.7" Hg
	P2C (MIN) 9.7" Hg (MAX) 53.7" Hg HRS = 96.4
1550	SHUTDOWN. 98.3 HRS
	2-26-87
0740	UNIT STARTED FOR OIL WARM UP.
0750	TEST CYCLE STARTED.
0900	RPM (MIN) 37,600 (MAX) 80,300 PIO = 50.0 PSIG
	TIT (MIN) 1171°F (MAX) 1242°F TIO = 195°F
	PIT (MIN) 8.1" Hg (MAX) 47.6" Hg
	P2C (MIN) 9.7" Hg (MAX) 53.6" Hg HRS = 99.6
0920	SHUTDOWN. END OF 100.0 HOUR TEST.

PAGE TIME: _____

TOTAL TIME: _____



APPENDIX F

TEST DATA – FOUR POINT BENDING

6. Four point bending test results

Group Number:	221	Number of Samples:	20
Engineer Name:	N. Nabb	Test Date (MM/DD/YY):	04/03/87
Vendor Name:	Kyocera SN220M	Material Name:	TECOM TV81
Material Type:	Silicon Nitride	Atmosphere:	Air
Specimen Geometry:	1		
Nominal Specimen Size:	1	Support Span (In.):	1.500
Specimen Condition:	As Received		
Testing Rate (In./Min):	0.02000		
Testing Temperature (°F):	72		
Elastic Modulus (MPSI):	43.00		
Remarks: Test bars were supplied by A.I.D.			

Group Number: 221

Specimen Number	Breaking Load (Lb)	Loading Rate (Lb/Min)	Thick (Bar, Tub, C-Ring) (In.)	Diameter (Tube, C-Ring) (In.)	Width (Bar, C-Ring) (In.)	Strain Rate (MI In./In./Sec)	Stress MOR (KSI)	Rank
015	307	620.000	0.126	0.000	0.250	68.12	87.0	1
003	336	720.000	0.126	0.000	0.250	79.13	95.2	2
017	360	725.000	0.126	0.000	0.250	79.65	102.0	3
009	360	722.000	0.126	0.000	0.250	79.37	102.0	4
006	373	730.000	0.126	0.000	0.250	80.20	105.7	5
005	378	738.000	0.126	0.000	0.250	81.08	107.1	6
013	387	732.000	0.126	0.000	0.250	80.42	109.7	7
010	392	737.000	0.126	0.000	0.250	80.97	111.1	8
020	395	745.000	0.126	0.000	0.250	81.85	112.0	9
007	396	740.000	0.126	0.000	0.250	81.30	112.2	10
016	402	745.000	0.126	0.000	0.250	81.85	113.9	11
001	407	687.000	0.126	0.000	0.250	75.48	115.4	12
002	410	694.000	0.126	0.000	0.250	76.24	116.2	13
012	411	743.000	0.126	0.000	0.250	81.67	116.5	14
014	413	743.000	0.126	0.000	0.250	81.67	117.1	15
018	413	730.000	0.126	0.000	0.250	80.29	117.1	16
011	414	740.000	0.126	0.000	0.250	81.30	117.3	17
019	424	732.000	0.126	0.000	0.250	80.42	120.2	18
008	425	748.000	0.126	0.000	0.250	82.18	120.5	19
004	427	743.000	0.126	0.000	0.250	81.63	121.0	20

6. Four point bending test results

Group Number:	222	Number of Samples:	30
Engineer Name:	N. Nabb	Test Date (MM/DD/YY):	04/07/87
Vendor Name:	Kyocera	Material Name:	SN270M
Material Type:	Silicon Nitride	Atmosphere:	Air
Specimen Geometry:	1		
Nominal Specimen Size:	1	Support Span (In.):	1.500
Specimen Condition:	As Received		
Testing Rate (In./Min):	0.02000		
Testing Temperature (°F):	1200		
Elastic Modulus (MPSI):	43.00		
Remarks: Test bars were supplied by A.I.D.			

Group Number: 222

Specimen Number	Breaking Load (Lb)	Loading Rate (Lb/Min)	Thick (Bar, Tub, C-Ring) (In.)	Diameter (Tube, C-Ring) (In.)	Width (Bar, C-Ring) (In.)	Strain Rate (MI In./In./Sec)	Stress MOR (KSI)	Rank
039	246	501.000	0.126	0.000	0.250	55.04	69.7	1
025	308	563.000	0.126	0.000	0.250	61.85	87.3	2
038	320	477.000	0.126	0.000	0.250	52.40	90.7	3
033	327	414.000	0.126	0.000	0.250	45.48	92.7	4
024	327	611.000	0.126	0.000	0.250	67.13	92.7	5
037	328	549.000	0.126	0.000	0.250	60.31	93.0	6
040	329	496.000	0.126	0.000	0.250	54.49	93.3	7
030	335	577.000	0.126	0.000	0.250	63.39	95.0	8
027	336	606.000	0.126	0.000	0.250	66.58	95.2	9
036	338	547.000	0.126	0.000	0.250	60.12	95.8	10
028	341	586.000	0.126	0.000	0.250	64.38	96.7	11
021	342	641.000	0.126	0.000	0.250	70.42	96.9	12
032	347	529.000	0.126	0.000	0.250	58.12	98.4	13
034	350	563.000	0.126	0.000	0.250	61.85	99.2	14
022	356	593.000	0.126	0.000	0.250	65.15	100.9	15
031	359	583.000	0.126	0.000	0.250	64.05	101.8	16
029	370	647.000	0.126	0.000	0.250	71.08	104.9	17
035	371	604.000	0.126	0.000	0.250	66.36	105.2	18
023	393	626.000	0.126	0.000	0.250	68.77	111.4	19
026	400	630.000	0.126	0.000	0.250	69.21	113.4	20

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