FR-20710-4

SSME ALTERNATE TURBOPUMP DEVELOPMENT PROGRAM (HPFTP)

VERIFICATION COMPLETE REPORT SECOND TURBINE BLADE AERODYNAMIC DESIGN DVS DR NO. 3.1.2.2.4.1, VM NO. 4.1.2.4 A

JUNE 1989

Prepared under
NASA Contract NAS8-36801
DRL Sequence No. SE12
WBS No. 1.5.1.2

Prepared for
George C. Marshall Space Flight Center
National Aeronautics and Space Administration
Marshall Space Flight Center, Al 35812

Prepared by
Pratt & Whitney
P. O. Box 109600
West Palm Beach, FL 33410-9600

(NASA-CR-183753) SSME ALTERNATE TURBOPUMP DEVELOPMENT PROGRAM (HPFTP): VERIFICATION COMPLETE REPORT SECOND TURBINE BLADE AERODYNAMIC DESIGN DVS DR NO. 3.1.2.2.4.1, VM NO. 4.1.2.4 A (PWA) 42 p

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UNITED TECHNOLOGIES PRATT&WHITNEY

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Approved by:

John L. Price for
W. C. Shubert
ATD Project Manager

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HPFTP Turbine Aerodynamic Design

The High Pressure Fuel Turbopump (HPFTP) turbine aerodynamic design is based on the requirements defined by the Interface Control Document (ICD) and by the Power Balance Model, Table 387B. Performance Table 387B was used for the turbine aerodynamic design because its turbine flow capacities are consistent with the baseline turbine nozzle flow test results conducted on Pratt & Whitney's test stand, E-6, in December, 1986.

A conventional pressure-compounded, 2-stage turbine was chosen because of its inherent high efficiency over a wide range of steady-state operating conditions. No exit guide vane is required for the small (18 degrees) exit swirl angle. The high airfoil gas bending loads in the HPFTP turbine required thin wall, hollow airfoil sections, with larger moments of inertia, in order to reduce the airfoil bending stresses. The HPFTP turbine design has a mean diameter wheel speed of 1482 ft/sec which is compatible with allowable disk and root attachment stress criteria. This wheel speed also provides a high design point wheel speed to gas velocity ratio, assuring that there will not be a significant efficiency loss at minimum power level (MPL) operation. The design point velocity ratio, (0.55) is conservative, ensuring minimal aerodynamic risk. The design speed of approximately 36,500 rpm selected for the HPFTP was primarily set by the pump hydrodynamics. The height of the turbine annulus was selected to limit the last stage blade root centrifugal stress to 46,000 psi. This annulus size yielded a favorable exit Mach number of 0.18 and a low exit swirl angle of 18 degrees, therefore, this rpm was satisfactory to the performance, stress, and exit Mach number requirements of the turbine.

The methodology associated with the design of the HPFTP starts with the meanline design analysis. This analysis is based on the assumption that the flow through the turbine can be represented by the flow at the center of the flow passage. This simplified approach permits selection of the number of stages required, the mean diameter of the flow passage, and the annulus area. Included in the analysis is an estimate of the aerodynamic efficiency. This prediction system uses the physical laws of aerodynamics and correlations from rig and engine data to estimate profile loss, secondary loss, blade tip leakage, and shock and incidence losses based on the geometry and aerodynamic parameters of the turbine. An interactive graphic flowpath design system is used, in conjunction with the optimum meanline design, to generate candidate flowpath configurations.

The streamline design analysis is used to optimize the radial variation in the velocity triangles, once the average conditions are selected from the meanline analysis. This analysis calculates the flow characteristics at numerous radial locations and at the inlet and exit of each airfoil row. Once the meanline and streamline analyses have been used to optimize the velocity triangles throughout the turbine, 2 dimensional (2-D) airfoil sections are designed. These airfoil sections are designed to achieve contours that provide the desired amount of flow turning without permitting the flow to separate from

the airfoil surface. This process involves determining the static pressure distributions and boundary layer parameters along the airfoil surfaces and endwalls. An interactive graphics airfoil design system is used to identify adverse static pressure gradients such that the airfoil contour can be modified appropriately. After the 2-D airfoils are estimated at several spanwise locations, they are radially faired and combined with a preliminary endwall definition. An inviscid multi-stage 3-D flow analysis is then used to refine and optimize the entire flowpath configuration.

All turbine airfoil, endwall, inlet, and exit flow passage surfaces are contoured and refined as a system. The multi-stage feature enables a complete evaluation of potential changes to an individual surface contour during the design process. This assessment includes, not only flow property changes around the component being modified, but also around all upstream and downstream components in the complete turbine system. Improved performance and reduced risk result from this global optimization capability.

This report contains:

- Hot elevation diagrams for each airfoil
- 3-D airfoil plots
- 2-D airfoil section plots
- Tabulated airfoil section coordinates
- A plot of hot gaging dimensions versus radius
- A plot of percent change in flow area versus airfoil rotation
- A plot of stress versus span
- 3-D airfoil static pressure distributions
- Airfoil Ps/PT and Mach number contours
- A plot of suction surface boundary layer friction coefficient versus surface distance

COVER SHEET

S.S.M.E.

ENGINE Alternate Turbo-Pump Development

AIRFOIL 2nd Stage Blade

ENGINEER R.J. Rowey EXT 5962 DATE 8/24/87

AERODYNAMIC DESIGN POINT 100% Power - Design Table 0387.8 dated 4/10/87

F.T.D. LIST:

ELEVATION _____

AIRFOIL SECTIONS _____

AIRFOIL COORDINATES _____

DF LIST:

GAGING VS. RADIUS _____

FLOW AREA VS. ROTATION _____

STRESS VS. % SPAN _____

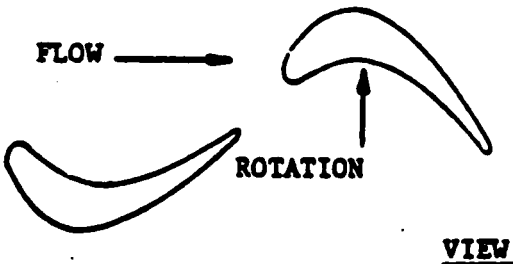
PRESSURE DIST. _____

BOUNDARY LAYER _____

CHECK ONE

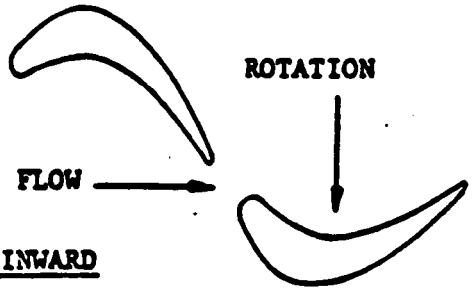
P&WA CONVENTIONAL ROTATION

VANE _____ BLADE ✓



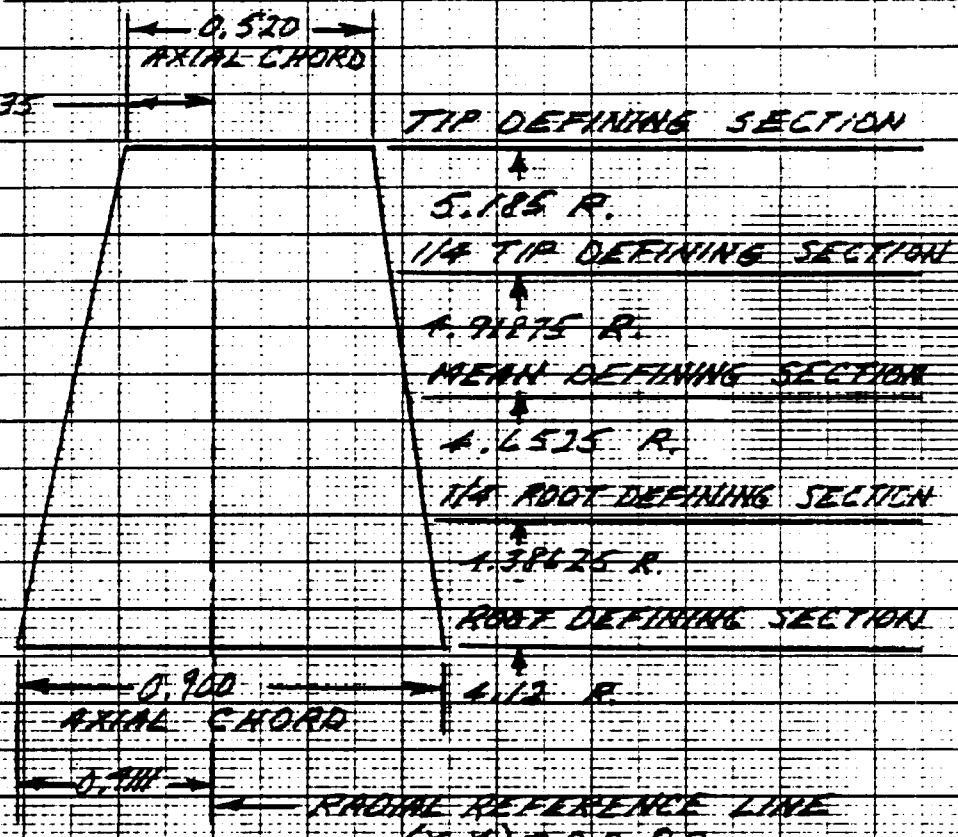
P&WA COUNTER ROTATION

VANE _____ BLADE _____



VIEW LOOKING RADIALLY INWARD

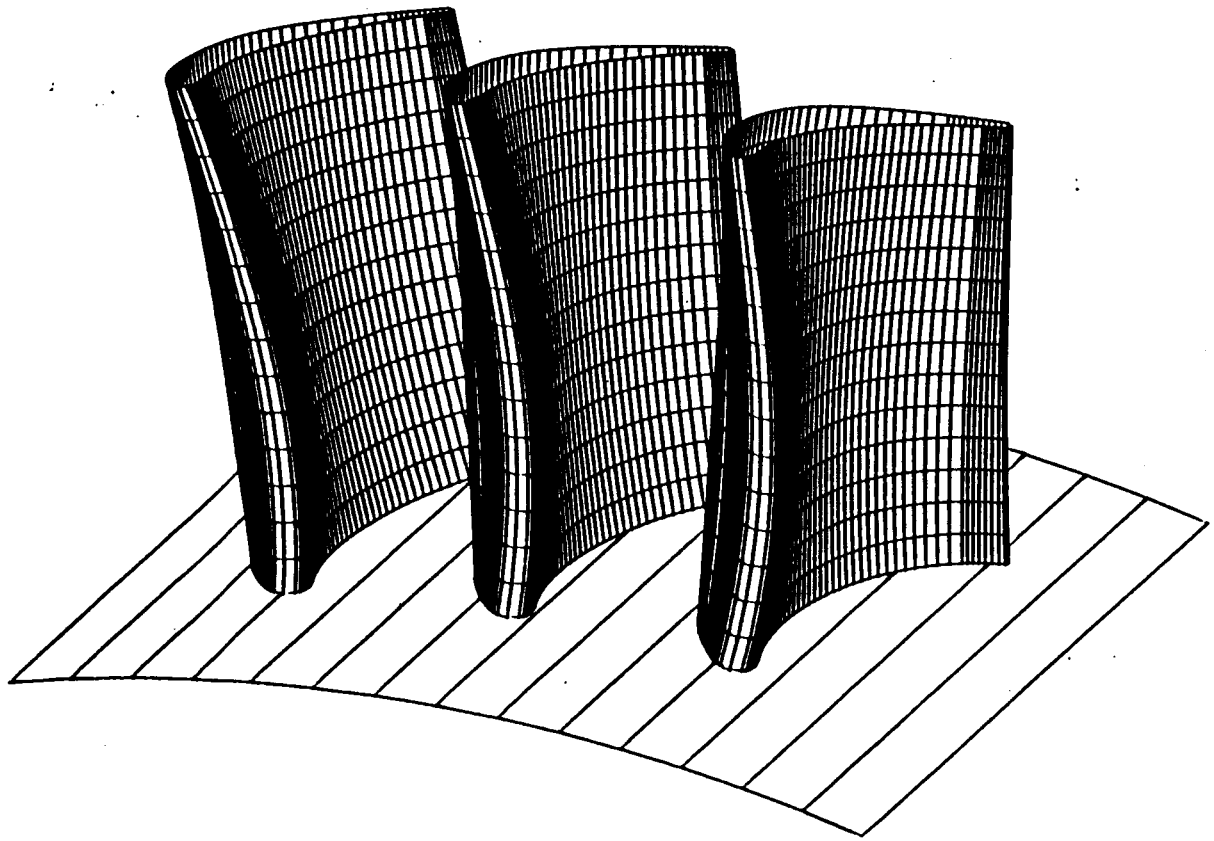
SSME HPFTP SECOND STAGE BLADE HOT ELEVATION



NOTES:
1. BLADE IS CURVED LINE FAIRED IN PP25.
2. NUMBER OF BLADES IS 50.
3. ALL DIMENSIONS ARE HOT.
4. MATERIAL IS PWA 1480, DENSITY IS 0.312 #/IN.
5. NET WEIGHT IS 0.03215 #/FOIL.
6. PULL IS 328.4 #/FOIL AT 36421 R.P.M.
7. AIRFOIL COORDINATES RESIDE IN PP25 FILE RJRPF24 BIFINAL.

R.J.R. 8/20/67

3DPLOT

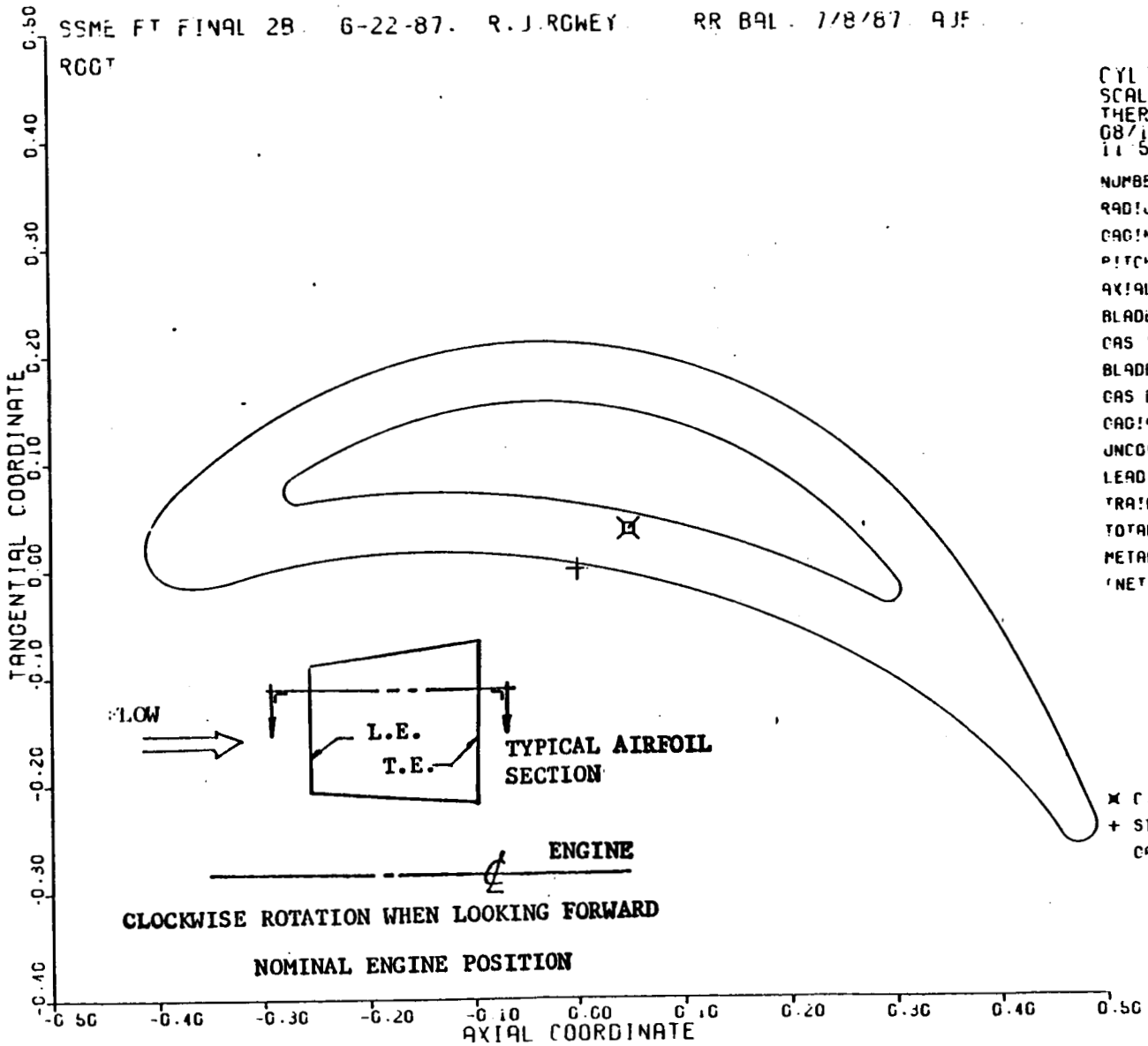


05/22/8714:35:04

SSME FT FINAL 2B.. 5-14-87.. R.J.ROWEY.. 42.88 58.59 42.14

SSME FT FINAL 2B 6-22-87. R.J.ROWEY RR BAL. 7/8/87 AJF

ROOT



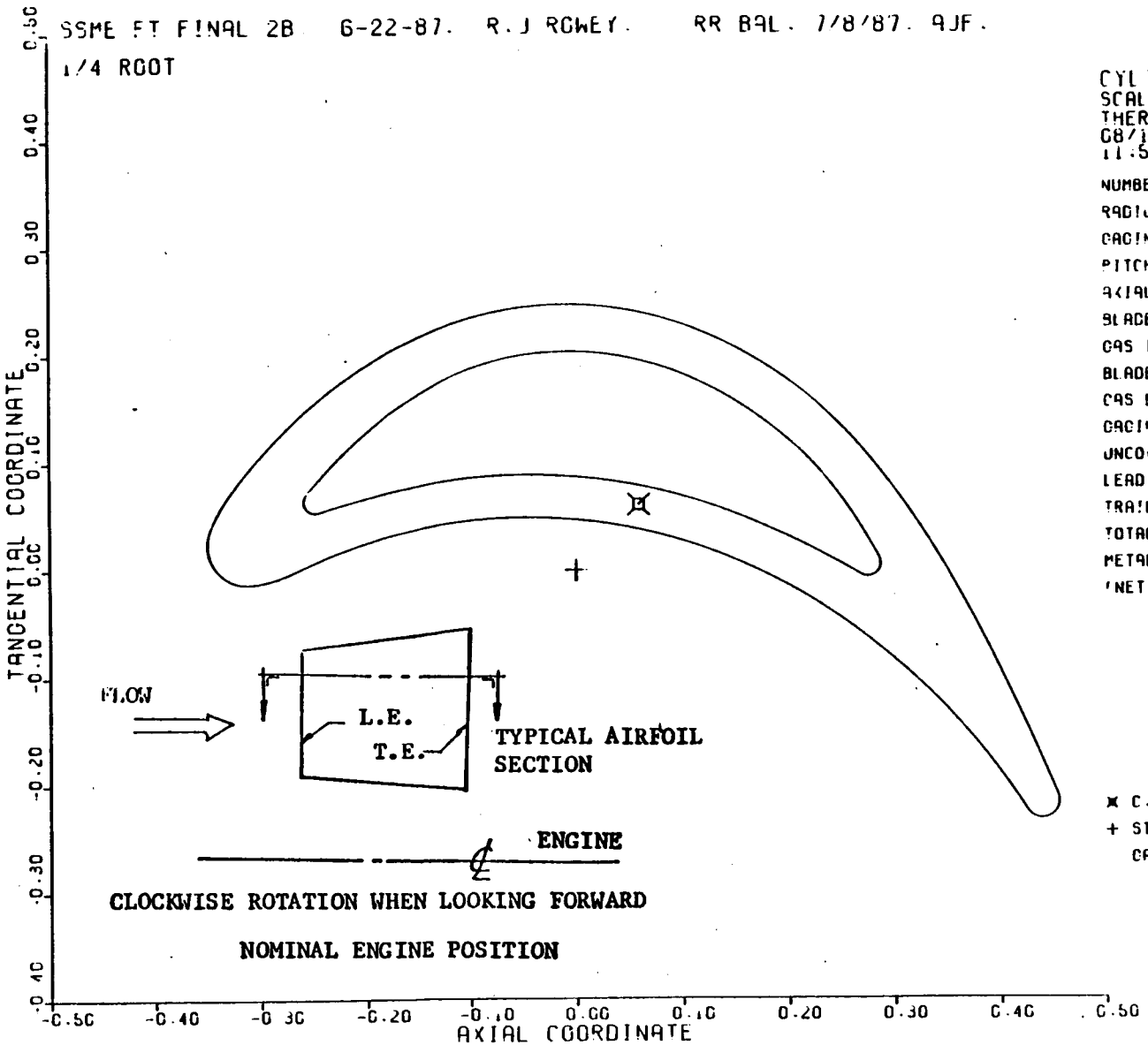
CYLINDRICAL
SCALE 10.0
THERMAL SHRINK FACTOR 1.000000
08/19/87
11:50:07

NUMBER OF BLADES	50.	
RADIUS (HOT)	4.120	INCHES
GAGING (HOT)	0.2491	INCHES
PITCH (HOT)	0.5177	INCHES
AXIAL WIDTH	0.9000	INCHES
BLADE INLET ANGLE	67.218	DEGREES
GAS INLET ANGLE	52.634	DEGREES
BLADE EXIT ANGLE	28.115	DEGREES
GAS EXIT ANGLE	28.117	DEGREES
GAGING ANGLE	28.761	DEGREES
UNCOVERED TURNING	23.292	DEGREES
LEADING EDGE RADIUS	0.0358	INCHES
TRAILING EDGE RADIUS	0.0175	INCHES
TOTAL AREA (SOLID)	0.1477	SQ. IN.
METAL AREA (NET, UNCOATED)	0.1056	SQ. IN.

	X	Y
✱ C.G.	0.0483	0.0000
+ STACKING LINE	0.0000	0.0000
GAGE	0.2891	0.0000

SSME FT FINAL 2B 6-22-87. R.J ROWEY. RR BAL. 7/8/87. AJF.

1/4 ROOT



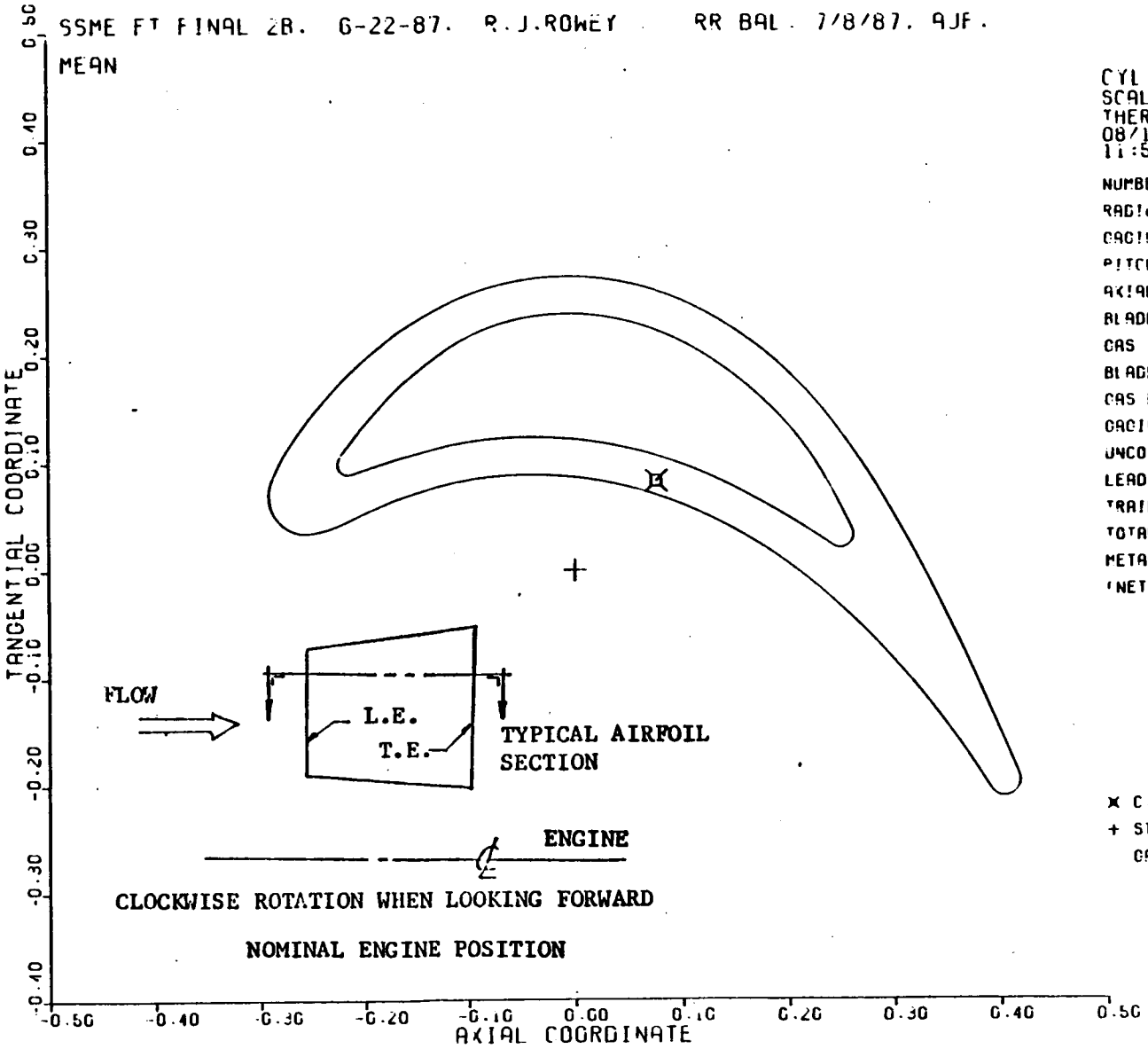
CYLINDRICAL
SCALE 10.0
THERMAL SHRINK FACTOR 1 000000
08/19/87
11:50.07

NUMBER OF BLADES	50.	
RADIUS (HOT)	4.386	INCHES
GAGING (HOT)	0.2590	INCHES
PITCH (HOT)	0.5512	INCHES
AXIAL WIDTH	0.8050	INCHES
BLADE INLET ANGLE	50.531	DEGREES
GAS INLET ANGLE	43.702	DEGREES
BLADE EXIT ANGLE	28.151	DEGREES
GAS EXIT ANGLE	28.117	DEGREES
GAGING ANGLE	28.023	DEGREES
UNCOVERED TURNING	21.988	DEGREES
LEADING EDGE RADIUS	0.0374	INCHES
TRAILING EDGE RADIUS	0.0163	INCHES
TOTAL AREA (SOLID)	0.1302	SQ. IN.
METAL AREA (NET, UNCOATED)	0.0808	SQ. IN.

	X	Y
✖ C.G.	0.0591	0.0000
+ STACKING LINE	0.0000	0.0000
GAGE	0.2462	0.0000

SSME FT FINAL 2B. 6-22-87. R.J.ROWEY RR BAL. 7/8/87. AJF.

MEAN



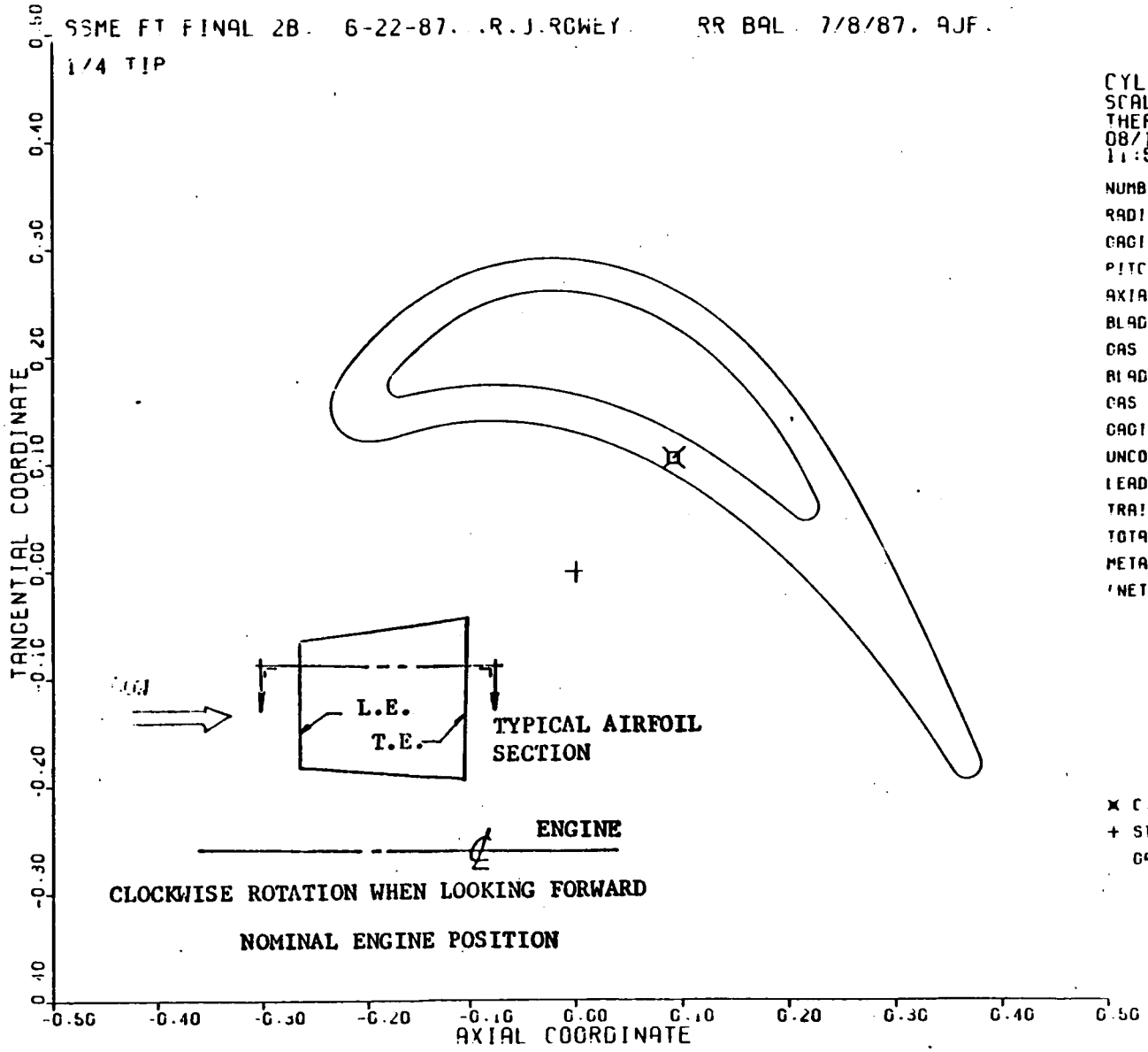
CYLINDRICAL
SCALE 10.0
THERMAL SHRINK FACTOR 1.000000
08/19/87
11:50.07

NUMBER OF BLADES	50.	
RADIUS (HOT)	4.652	INCHES
GAGING (HOT)	0.2735	INCHES
PITCH (HOT)	0.5846	INCHES
AXIAL WIDTH	0.7100	INCHES
BLADE INLET ANGLE	54.221	DEGREES
GAS INLET ANGLE	43.462	DEGREES
BLADE EXIT ANGLE	28.088	DEGREES
GAS EXIT ANGLE	28.117	DEGREES
GAGING ANGLE	27.891	DEGREES
UNCOVERED TURNING	22.354	DEGREES
LEADING EDGE RADIUS	0.0358	INCHES
TRAILING EDGE RADIUS	0.0150	INCHES
TOTAL AREA (SOLID)	0.1076	SQ. IN.
METAL AREA (NET. UNCOATED)	0.0629	SQ. IN.

	X	Y
X C.C.	0.0758	0.0000
+ STACKING LINE	0.0000	0.0000
GAGE	0.2026	0.0000

SSME FT FINAL 2B. 6-22-87. .R.J.ROWEY RR BAL 7/8/87. AJF.

1/4 TIP



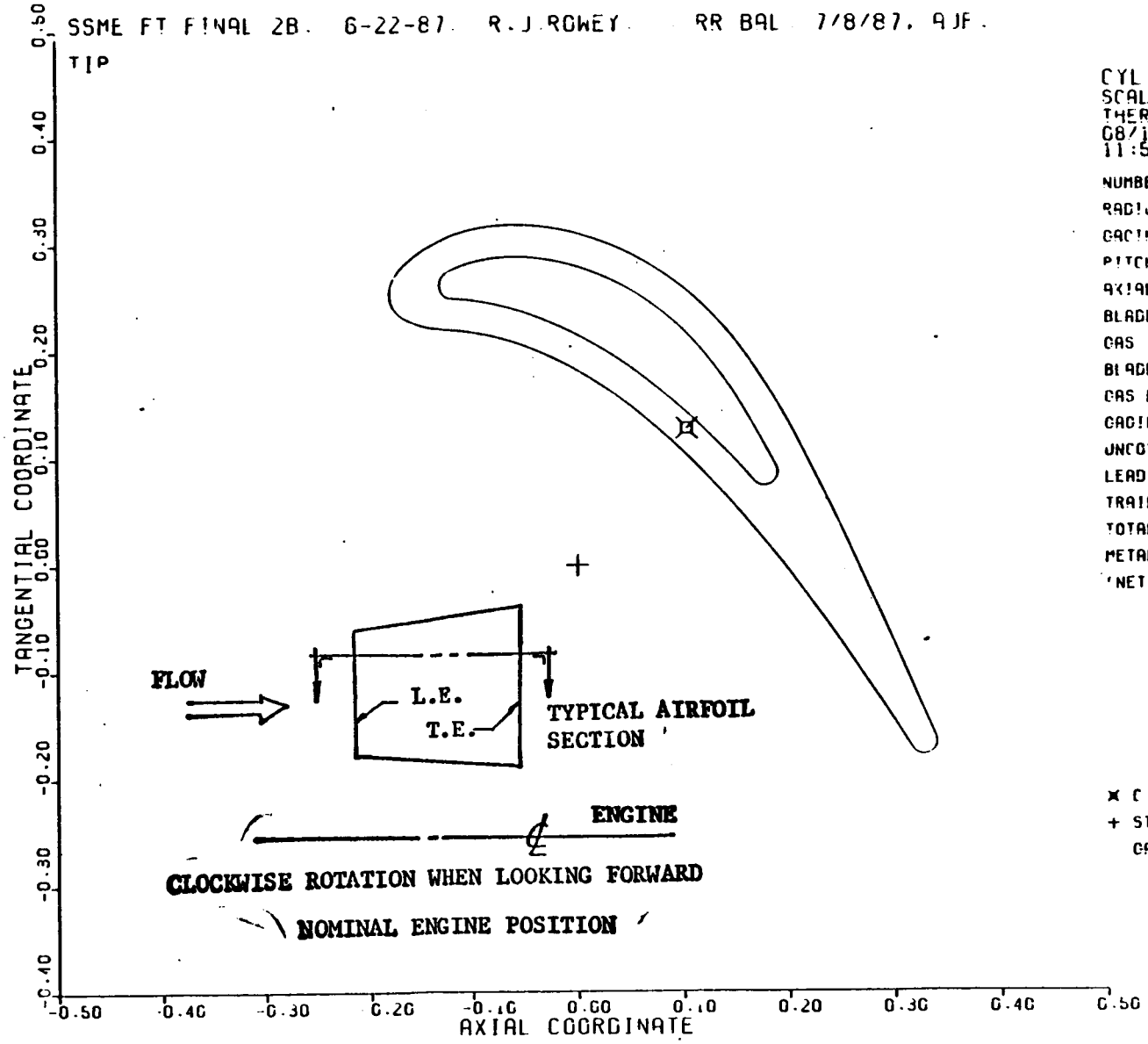
CYLINDRICAL
SCALE 10.0
THERMAL SHRINK FACTOR 1.000000
08/19/87
11:50.07

NUMBER OF BLADES	50.	
RADIUS (HOT)	4.919	INCHES
GAGING (HOT)	0.2914	INCHES
PITCH (HOT)	0.6181	INCHES
AXIAL WIDTH	0.0150	INCHES
BLADE INLET ANGLE	62.054	DEGREES
GAS INLET ANGLE	56.700	DEGREES
BLADE EXIT ANGLE	28.092	DEGREES
GAS EXIT ANGLE	28.117	DEGREES
GAGING ANGLE	28.124	DEGREES
UNCOVERED TURNING	23.061	DEGREES
LEADING EDGE RADIUS	0.0325	INCHES
TRAILING EDGE RADIUS	0.0137	INCHES
TOTAL AREA (SOLID)	0.0826	SQ. IN.
METAL AREA (NET, UNCOATED)	0.0509	SQ. IN.

	X	Y
✖ C.C.	0.0913	0.0000
+ STACKING LINE	0.0000	0.0000
GAGE	0.1562	0.0000

SSME FT FINAL 2B. 6-22-87. R.J.ROWEY. RR BAL 7/8/87. AJF.

TIP



CYLINDRICAL
SCALE 10.0
THERMAL SHRINK FACTOR 1.000000
08/19/87
11:50.07

NUMBER OF BLADES	50.	
RADIUS (HOT)	5.185	INCHES
GAPING (HOT)	0.3062	INCHES
PITCH (HOT)	0.6516	INCHES
AXIAL WIDTH	0.5200	INCHES
BLADE INLET ANGLE	83.551	DEGREES
GAS INLET ANGLE	88.868	DEGREES
BLADE EXIT ANGLE	28.090	DEGREES
GAS EXIT ANGLE	28.117	DEGREES
GAPING ANGLE	28.027	DEGREES
UNCOVERED TURNING	24.535	DEGREES
LEADING EDGE RADIUS	0.0257	INCHES
TRAILING EDGE RADIUS	0.0125	INCHES
TOTAL AREA (SOLID)	0.0594	SQ. IN.
METAL AREA (NET, UNCOATED)	0.0410	SQ. IN.

	X	Y
✱ C.C.	0.1033	0.0000
+ STACKING LINE	0.0000	0.0000
GAPE	0.1144	0.0000

EXTERNAL (OUR TITLE - SSME FT FINAL 2B...6-22-87...R.J. :Y... RR BAL. 7/8/87, AJF.
TD 0 .J REV. 0 PART NO. EMD NO. DATE 08/19/87 TIME 11:49:52 CYLINDRICAL
SUBTITLE ROOT HOT RADIUS = 4.12000 COLD RADIUS = 4.11071 THERMAL SHRINK FACTOR = 1.00000

PRETWIST NOT USED FOR TD PRINTOUT.

PCT X	X TOP	Y TOP	(CIRCLE)	X BOT	Y BOT	(CIRCLE)				
0.0	-0.41111	0.03019	0.02111	-0.41111	0.00469	0.02111				
0.010	-0.40211	0.04606		-0.40211	-0.00423	-0.00262				
0.020	-0.39311	0.05910		-0.39311	-0.01032	-0.00994				
0.030	-0.38411	0.06931		-0.38411	-0.01358					
0.040	-0.37511	0.07793		-0.37511	-0.01526					
0.050	-0.36611	0.08567		-0.36611	-0.01583					
0.060	-0.35711	0.09309		-0.35711	-0.01555					
0.070	-0.34811	0.10021		-0.34811	-0.01456		L.E. CIRCLE (X,Y,R)	-0.37533	0.02111	0.03578
0.080	-0.33911	0.10705		-0.33911	-0.01296		T.E. CIRCLE (X,Y,R)	0.47139	-0.24143	0.01750
0.090	-0.33011	0.11362		-0.33011	-0.01080					
0.100	-0.32111	0.11992		-0.32111	-0.00817		L.E. TOP TANG. PT. (X,Y)	-0.40641	0.03884	
0.125	-0.29861	0.13457		-0.29861	-0.00201		L.E. BOTTOM TANG. PT. (X,Y)	-0.38443	-0.01350	
0.150	-0.27611	0.14775		-0.27611	0.00312		T.E. TOP TANG. PT. (X,Y)	0.48743	-0.23444	
0.175	-0.25361	0.15953		-0.25361	0.00732		T.E. BOTTOM TANG. PT. (X,Y)	0.45666	-0.25088	
0.200	-0.23111	0.16999		-0.23111	0.01066					
0.225	-0.20861	0.17920		-0.20861	0.01321		NOSE POINT (X,Y)	-0.40832	0.00725	
0.250	-0.18611	0.18720		-0.18611	0.01500		TAIL POINT (X,Y)	0.47964	-0.25686	
0.275	-0.16361	0.19403		-0.16361	0.01609					
0.300	-0.14111	0.19973		-0.14111	0.01650		NET CROSS-SECT. AREA (EXCL. COATING)	0.10564		
0.325	-0.11861	0.20432		-0.11861	0.01625					
0.350	-0.09611	0.20782		-0.09611	0.01538		GAGING (X,Y,LAMBDA)	0.28907	0.08178	0.24911
0.375	-0.07361	0.21023		-0.07361	0.01388		GAGING ANGLE (DEG.)	28.761		
0.400	-0.05111	0.21157		-0.05111	0.01178					
0.425	-0.02861	0.21183		-0.02861	0.00908		CTR. OF GRAV. (INCL. COATING) (X,Y)	0.04826	0.03735	
0.450	-0.00611	0.21101		-0.00611	0.00579		RAD. REF. PT. (X,Y)	0.0	0.0	
0.475	0.01639	0.20909		0.01639	0.00190		INLET ANGLE (DEG.)	67.218		
0.500	0.03889	0.20606		0.03889	-0.00259		INLET WEDGE ANGLE (DEG.)	75.025		
0.525	0.06139	0.20189		0.06139	-0.00768		EXIT ANGLE (DEG.)	28.115		
0.550	0.08389	0.19654		0.08389	-0.01339		EXIT WEDGE ANGLE (DEG.)	9.103		
0.575	0.10639	0.18999		0.10639	-0.01972		UNCOVERED TURNING ANGLE (DEG.)	23.292		
0.600	0.12889	0.18216		0.12889	-0.02671		AXIAL CHORD	0.90000		
0.625	0.15139	0.17301		0.15139	-0.03436		ACTUAL CHORD	0.93977		
0.650	0.17389	0.16245		0.17389	-0.04272		PITCH	0.51773		
0.675	0.19639	0.15040		0.19639	-0.05183		NO. OF FOILS	50		
0.700	0.21889	0.13672		0.21889	-0.06171					
0.725	0.24139	0.12127		0.24139	-0.07245					
0.750	0.26389	0.10387		0.26389	-0.08410					
0.775	0.28639	0.08427		0.28639	-0.09675					
0.800	0.30889	0.06217		0.30889	-0.11054					
0.825	0.33139	0.03718		0.33139	-0.12561					
0.850	0.35389	0.00896		0.35389	-0.14216					
0.875	0.37639	-0.02281		0.37639	-0.16051					
0.900	0.39889	-0.05833		0.39889	-0.18108					
0.910	0.40789	-0.07362		0.40789	-0.19007					
0.920	0.41689	-0.08953		0.41689	-0.19960					
0.930	0.42589	-0.10605		0.42589	-0.20973					
0.940	0.43489	-0.12317		0.43489	-0.22059					
0.950	0.44389	-0.14089		0.44389	-0.23231					
0.960	0.45289	-0.15918		0.45289	-0.24512					
0.970	0.46189	-0.17804		0.46189	-0.25934	-0.25613				
0.980	0.47089	-0.19744		0.47089	-0.27552	-0.25892				
0.990	0.47989	-0.21736		0.47989	-0.29474	-0.25673				
1.000	0.48889	-0.23778	-0.24143	0.48889	-0.31980	-0.24143				

NO. 1 CORI NTOUR TITLE - SSME FT FINAL 2B...6-22-87...R.J. :Y... RR BAL. 7/8/87, AJF.
TD 6 .J REV. 0 PART NO. EMD NO. Date 08/19/87 TIME 11:49:52 CYLINDRICAL
SUBTITLE ROOT HOT RADIUS = 4.12000 COLD RADIUS = 4.11071 THERMAL SHRINK FACTOR = 1.00000

PRETWIST NOT USED FOR TD PRINTOUT.

PCT X	X TOP	Y TOP	(CIRCLE)	X BOT	Y BOT	(CIRCLE)				
0.0	-0.27941	0.08092	0.07411	-0.27941	0.05916	0.07411				
0.010	-0.27358	0.08467		-0.27358	0.06026	0.06355				
0.020	-0.26774	0.08830		-0.26774	0.06131	0.06166				
0.030	-0.26191	0.09182		-0.26191	0.06230					
0.040	-0.25608	0.09522		-0.25608	0.06324					
0.050	-0.25024	0.09852		-0.25024	0.06413					
0.060	-0.24441	0.10172		-0.24441	0.06497					
0.070	-0.23858	0.10481		-0.23858	0.06575		L.E. CIRCLE (X,Y,R)	-0.26693	0.07411	0.01248
0.080	-0.23275	0.10780		-0.23275	0.06649		T.E. CIRCLE (X,Y,R)	0.29141	-0.02155	0.01248
0.090	-0.22691	0.11069		-0.22691	0.06719					
0.100	-0.22108	0.11349		-0.22108	0.06783		L.E. TOP TANG. PT. (X,Y)	-0.27361	0.08465	
0.125	-0.20650	0.12006		-0.20650	0.06923		L.E. BOTTOM TANG. PT. (X,Y)	-0.26484	0.06181	
0.150	-0.19192	0.12605		-0.19192	0.07037		T.E. TOP TANG. PT. (X,Y)	0.30122	-0.01383	
0.175	-0.17733	0.13146		-0.17733	0.07122		T.E. BOTTOM TANG. PT. (X,Y)	0.28556	-0.03258	
0.200	-0.16275	0.13630		-0.16275	0.07180					
0.225	-0.14817	0.14058		-0.14817	0.07210		NOSE POINT (X,Y)	-0.27858	0.06963	
0.250	-0.13359	0.14434		-0.13359	0.07214		TAIL POINT (X,Y)	0.30098	-0.02955	
0.275	-0.11900	0.14758		-0.11900	0.07193					
0.300	-0.10442	0.15031		-0.10442	0.07147					
0.325	-0.08984	0.15251		-0.08984	0.07077					
0.350	-0.07526	0.15421		-0.07526	0.06982					
0.375	-0.06067	0.15538		-0.06067	0.06864					
0.400	-0.04609	0.15605		-0.04609	0.06721					
0.425	-0.03151	0.15621		-0.03151	0.06555					
0.450	-0.01693	0.15585		-0.01693	0.06366					
0.475	-0.00234	0.15496		-0.00234	0.06153					
0.500	0.01224	0.15356		0.01224	0.05916					
0.525	0.02682	0.15162		0.02682	0.05656					
0.550	0.04140	0.14914		0.04140	0.05373					
0.575	0.05599	0.14610		0.05599	0.05065					
0.600	0.07057	0.14251		0.07057	0.04734					
0.625	0.08515	0.13833		0.08515	0.04378					
0.650	0.09973	0.13355		0.09973	0.03998					
0.675	0.11432	0.12815		0.11432	0.03593					
0.700	0.12890	0.12211		0.12890	0.03163					
0.725	0.14348	0.11540		0.14348	0.02706					
0.750	0.15806	0.10799		0.15806	0.02223					
0.775	0.17265	0.09984		0.17265	0.01714					
0.800	0.18723	0.09091		0.18723	0.01176					
0.825	0.20181	0.08115		0.20181	0.00610					
0.850	0.21639	0.07050		0.21639	0.00014					
0.875	0.23098	0.05888		0.23098	-0.00613					
0.900	0.24556	0.04620		0.24556	-0.01273					
0.910	0.25139	0.04082		0.25139	-0.01546					
0.920	0.25723	0.03524		0.25723	-0.01825					
0.930	0.26306	0.02946		0.26306	-0.02109					
0.940	0.26889	0.02347		0.26889	-0.02399					
0.950	0.27472	0.01726		0.27472	-0.02694					
0.960	0.28056	0.01084		0.28056	-0.02995					
0.970	0.28639	0.00419		0.28639	-0.03302	-0.03298				
0.980	0.29222	-0.00271		0.29222	-0.03615	-0.03401				
0.990	0.29806	-0.00985		0.29806	-0.03935	-0.03211				
1.000	0.30389	-0.01725	-0.02155	0.30389	-0.04261	-0.02155				

EXTERNAL (OUR TITLE - SSME FT FINAL 2B...6-22-87...R.J. :Y... RR BAL. 7/8/87, AJF.
TD 0 .J REV. 0 PART NO. EMD NO. DA:E 08/19/87 TIME 11:49:52 CYLINDRICAL
S:BTITLE 1/4 ROOT HOT RADIUS = 4.38625 COLD RADIUS = 4.37389 THERMAL SHRINK FACTOR = 1.00000

PRETWIST NOT USED FOR TD PRINTOUT.

PCT X	X TOP	Y TOP	(CIRCLE)	X BOT	Y BOT	(CIRCLE)				
0.0	-0.35001	0.03218	0.02417	-0.35001	0.00546	0.02417				
0.010	-0.34196	0.04926		-0.34196	-0.00329	0.00099				
0.020	-0.33391	0.06346		-0.33391	-0.00909	-0.00657				
0.030	-0.32586	0.07478		-0.32586	-0.01191	-0.01080				
0.040	-0.31781	0.08503		-0.31781	-0.01310	-0.01286				
0.050	-0.30976	0.09467		-0.30976	-0.01313					
0.060	-0.30171	0.10390		-0.30171	-0.01227					
0.070	-0.29366	0.11272		-0.29366	-0.01067		L.E. CIRCLE (X,Y,R)	-0.31262	0.02417	0.03739
0.080	-0.28561	0.12115		-0.28561	-0.00842		T.E. CIRCLE (X,Y,R)	0.43874	-0.21662	0.01625
0.090	-0.27756	0.12922		-0.27756	-0.00561					
0.100	-0.26951	0.13693		-0.26951	-0.00227		L.E. TOP TANG. PT. (X,Y)	-0.34649	0.03999	
0.125	-0.24938	0.15477		-0.24938	0.00689		L.E. BOTTOM TANG. PT. (X,Y)	-0.31133	-0.01320	
0.150	-0.22926	0.17070		-0.22926	0.01518		T.E. TOP TANG. PT. (X,Y)	0.45363	-0.21011	
0.175	-0.20913	0.18487		-0.20913	0.02251		T.E. BOTTOM TANG. PT. (X,Y)	0.42507	-0.22540	
0.200	-0.18901	0.19741		-0.18901	0.02890					
0.225	-0.16888	0.20841		-0.16888	0.03439		NOSE POINT (X,Y)	-0.34381	0.00355	
0.250	-0.14876	0.21795		-0.14876	0.03901		TAIL POINT (X,Y)	0.44641	-0.23095	
0.275	-0.12863	0.22609		-0.12863	0.04276					
0.300	-0.10851	0.23290		-0.10851	0.04567		NET CROSS-SECT. AREA (EXCL. COATING)	0.08082		
0.325	-0.08838	0.23840		-0.08838	0.04776					
0.350	-0.06826	0.24264		-0.06826	0.04902		GAGING (X,Y,LAMBDA)	0.24617	0.13795	0.25897
0.375	-0.04813	0.24561		-0.04813	0.04946		GAGING ANGLE (DEG.)	28.023		
0.400	-0.02801	0.24735		-0.02801	0.04910					
0.425	-0.00788	0.24787		-0.00788	0.04791		CTR. OF GRAV. (INCL. COATING) (X,Y)	0.05911	0.06106	
0.450	0.01224	0.24715		0.01224	0.04590		RAD. REF. PT. (X,Y)	0.0	0.0	
0.475	0.03237	0.24519		0.03237	0.04308		INLET ANGLE (DEG.)	56.531		
0.500	0.05249	0.24198		0.05249	0.03940		INLET WEDGE ANGLE (DEG.)	62.981		
0.525	0.07262	0.23750		0.07262	0.03489		EXIT ANGLE (DEG.)	28.151		
0.550	0.09274	0.23171		0.09274	0.02951		EXIT WEDGE ANGLE (DEG.)	9.086		
0.575	0.11287	0.22461		0.11287	0.02324		UNCOVERED TURNING ANGLE (DEG.)	21.988		
0.600	0.13299	0.21612		0.13299	0.01606		AXIAL CHORD	0.80500		
0.625	0.15312	0.20622		0.15312	0.00796		ACTUAL CHORD	0.84264		
0.650	0.17324	0.19479		0.17324	-0.00112		PITCH	0.55119		
0.675	0.19337	0.18171		0.19337	-0.01120		NO. OF FOILS	50		
0.700	0.21349	0.16679		0.21349	-0.02233					
0.725	0.23362	0.14976		0.23362	-0.03455					
0.750	0.25374	0.13035		0.25374	-0.04793					
0.775	0.27387	0.10833		0.27387	-0.06252					
0.800	0.29399	0.08353		0.29399	-0.07843					
0.825	0.31412	0.05583		0.31412	-0.09575					
0.850	0.33424	0.02521		0.33424	-0.11459					
0.875	0.35437	-0.00829		0.35437	-0.13515					
0.900	0.37449	-0.04454		0.37449	-0.15764					
0.910	0.38254	-0.05977		0.38254	-0.16723					
0.920	0.39059	-0.07540		0.39059	-0.17721					
0.930	0.39864	-0.09143		0.39864	-0.18762					
0.940	0.40669	-0.10783		0.40669	-0.19849					
0.950	0.41474	-0.12459		0.41474	-0.20989					
0.960	0.42279	-0.14169		0.42279	-0.22189					
0.970	0.43084	-0.15913		0.43084	-0.23461	-0.23082				
0.980	0.43889	-0.17687		0.43889	-0.24825	-0.23287				
0.990	0.44694	-0.19490		0.44694	-0.26320	-0.23065				
1.000	0.45499	-0.21323	-0.21662	0.45499	-0.28042	-0.21662				

NO. 1 CORI NTOUR TITLE - SSME FT FINAL 2B...6-22-87...R.J. :Y... RR BAL. 7/8/87, AJF.
TD 0 .J REV. 0 PART NO. EMD NO. DA:E 08/19/87 TIME 11:49:52 CYLINDRICAL
SUBTITLE 1/4 ROOT HOT RADIUS = 4.38625 COLD RADIUS = 4.37389 THERMAL SHRINK FACTOR = 1.00000

PRETWIST NOT USED FOR TD PRINTOUT.

PCT X	X TOP	Y TOP	(CIRCLE)	X BOT	Y BOT	(CIRCLE)				
0.0	-0.25892	0.06823	0.06434	-0.25892	0.04951	0.06434				
0.010	-0.25346	0.07468		-0.25346	0.05138	0.05502				
0.020	-0.24799	0.08094		-0.24799	0.05319	0.05366				
0.030	-0.24253	0.08703		-0.24253	0.05496					
0.040	-0.23707	0.09294		-0.23707	0.05667					
0.050	-0.23160	0.09867		-0.23160	0.05835					
0.060	-0.22614	0.10423		-0.22614	0.05997					
0.070	-0.22068	0.10960		-0.22068	0.06156		L.E. CIRCLE (X,Y,R)	-0.24824	0.06434	0.01068
0.080	-0.21521	0.11480		-0.21521	0.06312		T.E. CIRCLE (X,Y,R)	0.27518	0.00537	0.01222
0.090	-0.20975	0.11981		-0.20975	0.06464					
0.100	-0.20429	0.12466		-0.20429	0.06613		L.E. TOP TANG. PT. (X,Y)	-0.25639	0.07124	
0.125	-0.19063	0.13605		-0.19063	0.06971		L.E. BOTTOM TANG. PT. (X,Y)	-0.24496	0.05418	
0.150	-0.17697	0.14644		-0.17697	0.07308		T.E. TOP TANG. PT. (X,Y)	0.28582	0.01138	
0.175	-0.16331	0.15591		-0.16331	0.07622		T.E. BOTTOM TANG. PT. (X,Y)	0.26909	-0.00523	
0.200	-0.14966	0.16447		-0.14966	0.07910					
0.225	-0.13600	0.17214		-0.13600	0.08164		NOSE POINT (X,Y)	-0.25711	0.05840	
0.250	-0.12234	0.17893		-0.12234	0.08378		TAIL POINT (X,Y)	0.28379	-0.00330	
0.275	-0.10868	0.18487		-0.10868	0.08555					
0.300	-0.09502	0.18998		-0.09502	0.08698					
0.325	-0.08137	0.19425		-0.08137	0.08806					
0.350	-0.06771	0.19771		-0.06771	0.08878					
0.375	-0.05405	0.20038		-0.05405	0.08915					
0.400	-0.04039	0.20231		-0.04039	0.08918					
0.425	-0.02673	0.20355		-0.02673	0.08885					
0.450	-0.01308	0.20412		-0.01308	0.08818					
0.475	0.00058	0.20403		0.00058	0.08716					
0.500	0.01424	0.20330		0.01424	0.08577					
0.525	0.02790	0.20189		0.02790	0.08405					
0.550	0.04156	0.19980		0.04156	0.08196					
0.575	0.05521	0.19704		0.05521	0.07952					
0.600	0.06887	0.19359		0.06887	0.07672					
0.625	0.08253	0.18942		0.08253	0.07356					
0.650	0.09619	0.18454		0.09619	0.07002					
0.675	0.10985	0.17892		0.10985	0.06611					
0.700	0.12350	0.17254		0.12350	0.06183					
0.725	0.13716	0.16537		0.13716	0.05716					
0.750	0.15082	0.15739		0.15082	0.05208					
0.775	0.16448	0.14853		0.16448	0.04659					
0.800	0.17814	0.13871		0.17814	0.04074					
0.825	0.19179	0.12796		0.19179	0.03462					
0.850	0.20545	0.11630		0.20545	0.02821					
0.875	0.21911	0.10348		0.21911	0.02156					
0.900	0.23277	0.08894		0.23277	0.01461					
0.910	0.23823	0.08253		0.23823	0.01176					
0.920	0.24369	0.07576		0.24369	0.00885					
0.930	0.24916	0.06863		0.24916	0.00591					
0.940	0.25462	0.06113		0.25462	0.00292					
0.950	0.26008	0.05326		0.26008	-0.00012					
0.960	0.26555	0.04500		0.26555	-0.00320					
0.970	0.27101	0.03639		0.27101	-0.00633	-0.00612				
0.980	0.27647	0.02744		0.27647	-0.00950	-0.00678				
0.990	0.28194	0.01817		0.28194	-0.01271	-0.00481				
1.000	0.28740	0.00858	0.00537	0.28740	-0.01597	0.00537				

EXTERNAL (OUR TITLE - SSME FT FINAL 2B...6-22-87...R.J. :Y... RR BAL. 7/8/87, AJF.
TD 0 .0 REV. 0 PART NO. EMD NO. DA:E 08/19/87 TIME 11:49:52 CYLINDRICAL
SUBTITLE MEAN HOT RADIUS = 4.65250 COLD RADIUS = 4.63684 THERMAL SHRINK FACTOR = 1.00000

PRETWIST NOT USED FOR TD PRINTOUT.

PCT X	X TOP	Y TOP	(CIRCLE)	X BOT	Y BOT	(CIRCLE)				
0.0	-0.29155	0.07744	0.07018	-0.29155	0.05235	0.07018				
0.010	-0.28445	0.09343		-0.28445	0.04405	0.04879				
0.020	-0.27735	0.10675		-0.27735	0.03851	0.04165				
0.030	-0.27025	0.11741		-0.27025	0.03574	0.03747				
0.040	-0.26315	0.12725		-0.26315	0.03450	0.03518				
0.050	-0.25605	0.13659		-0.25605	0.03433	0.03442				
0.060	-0.24895	0.14547		-0.24895	0.03498					
0.070	-0.24185	0.15390		-0.24185	0.03631		L.E. CIRCLE (X,Y,R)	-0.25578	0.07018	0.03577
0.080	-0.23475	0.16192		-0.23475	0.03823		T.E. CIRCLE (X,Y,R)	0.40345	-0.19638	0.01500
0.090	-0.22765	0.16956		-0.22765	0.04067					
0.100	-0.22055	0.17682		-0.22055	0.04360		L.E. TOP TANG. PT. (X,Y)	-0.28853	0.08457	
0.125	-0.20280	0.19348		-0.20280	0.05208		L.E. BOTTOM TANG. PT. (X,Y)	-0.25249	0.03456	
0.150	-0.18505	0.20818		-0.18505	0.05980		T.E. TOP TANG. PT. (X,Y)	0.41720	-0.19039	
0.175	-0.16730	0.22110		-0.16730	0.06659		T.E. BOTTOM TANG. PT. (X,Y)	0.39082	-0.20447	
0.200	-0.14955	0.23238		-0.14955	0.07245					
0.225	-0.13180	0.24213		-0.13180	0.07740		NOSE POINT (X,Y)	-0.28480	0.04927	
0.250	-0.11405	0.25044		-0.11405	0.08146		TAIL POINT (X,Y)	0.41051	-0.20961	
0.275	-0.09630	0.25737		-0.09630	0.08462					
0.300	-0.07855	0.26299		-0.07855	0.08690		NET CROSS-SECT. AREA (EXCL. COATING)	0.06294		
0.325	-0.06080	0.26733		-0.06080	0.08830					
0.350	-0.04305	0.27043		-0.04305	0.08882		GAGING (X,Y,LAMBDA)	0.20263	0.18114	0.27350
0.375	-0.02530	0.27230		-0.02530	0.08847		GAGING ANGLE (DEG.)	27.891		
0.400	-0.00755	0.27296		-0.00755	0.08725					
0.425	0.01020	0.27242		0.01020	0.08514		CTR. OF GRAV. (INCL. COATING) (X,Y)	0.07580	0.08284	
0.450	0.02795	0.27067		0.02795	0.08215		RAD. REF. PT. (X,Y)	0.0	0.0	
0.475	0.04570	0.26769		0.04570	0.07828		INLET ANGLE (DEG.)	54.221		
0.500	0.06345	0.26347		0.06345	0.07350		INLET WEDGE ANGLE (DEG.)	60.990		
0.525	0.08120	0.25797		0.08120	0.06782		EXIT ANGLE (DEG.)	28.088		
0.550	0.09895	0.25116		0.09895	0.06122		EXIT WEDGE ANGLE (DEG.)	9.098		
0.575	0.11670	0.24298		0.11670	0.05368		UNCOVERED TURNING ANGLE (DEG.)	22.354		
0.600	0.13445	0.23336		0.13445	0.04519		AXIAL CHORD	0.71000		
0.625	0.15220	0.22222		0.15220	0.03573		ACTUAL CHORD	0.76185		
0.650	0.16995	0.20944		0.16995	0.02527		PITCH	0.58465		
0.675	0.18770	0.19488		0.18770	0.01379		NO. OF FOILS	50		
0.700	0.20545	0.17838		0.20545	0.00126					
0.725	0.22320	0.15970		0.22320	-0.01236					
0.750	0.24095	0.13863		0.24095	-0.02710					
0.775	0.25870	0.11504		0.25870	-0.04301					
0.800	0.27645	0.08888		0.27645	-0.06014					
0.825	0.29420	0.06021		0.29420	-0.07854					
0.850	0.31195	0.02919		0.31195	-0.09828					
0.875	0.32970	-0.00398		0.32970	-0.11944					
0.900	0.34745	-0.03904		0.34745	-0.14211					
0.910	0.35455	-0.05353		0.35455	-0.15161					
0.920	0.36165	-0.06826		0.36165	-0.16138					
0.930	0.36875	-0.08323		0.36875	-0.17143					
0.940	0.37585	-0.09841		0.37585	-0.18175					
0.950	0.38295	-0.11379		0.38295	-0.19236					
0.960	0.39005	-0.12936		0.39005	-0.20327					
0.970	0.39715	-0.14510		0.39715	-0.21449	-0.20999				
0.980	0.40425	-0.16100		0.40425	-0.22602	-0.21136				
0.990	0.41135	-0.17705		0.41135	-0.23789	-0.20913				
1.000	0.41845	-0.19325	-0.19638	0.41845	-0.25010	-0.19638				

NO. 1 CORI NTOUR TITLE - SSME FT FINAL 2B...6-22-87...R.J. :Y... RR BAL. 7/8/87, AJF.
TD 6 .J REV. 0 PART NO. EMD NO. DA:E 08/19/87 TIME 11:49:52 CYLINDRICAL
SUBTITLE MEAN HOT RADIUS = 4.65250 COLD RADIUS = 4.63684 THERMAL SHRINK FACTOR = 1.00000

PRETWIST NOT USED FOR TD PRINTOUT.

PCT X	X TOP	Y TOP	(CIRCLE)	X BOT	Y BOT	(CIRCLE)				
0.0	-0.22575	0.10212	0.09889	-0.22575	0.08470	0.09889				
0.010	-0.22088	0.10883		-0.22088	0.08646	0.09030				
0.020	-0.21600	0.11534		-0.21600	0.08819	0.08888				
0.030	-0.21113	0.12165		-0.21113	0.08989					
0.040	-0.20626	0.12776		-0.20626	0.09156					
0.050	-0.20139	0.13367		-0.20139	0.09319					
0.060	-0.19651	0.13939		-0.19651	0.09479					
0.070	-0.19164	0.14490		-0.19164	0.09636		L.E. CIRCLE (X,Y,R)	-0.21573	0.09889	0.01002
0.080	-0.18677	0.15022		-0.18677	0.09791		T.E. CIRCLE (X,Y,R)	0.24904	0.03228	0.01251
0.090	-0.18189	0.15535		-0.18189	0.09942					
0.100	-0.17702	0.16029		-0.17702	0.10090		L.E. TOP TANG. PT. (X,Y)	-0.22385	0.10476	
0.125	-0.16484	0.17186		-0.16484	0.10445		L.E. BOTTOM TANG. PT. (X,Y)	-0.21245	0.08943	
0.150	-0.15266	0.18237		-0.15266	0.10781		T.E. TOP TANG. PT. (X,Y)	0.26027	0.03779	
0.175	-0.14047	0.19190		-0.14047	0.11097		T.E. BOTTOM TANG. PT. (X,Y)	0.24211	0.02187	
0.200	-0.12829	0.20047		-0.12829	0.11388					
0.225	-0.11611	0.20811		-0.11611	0.11643		NOSE POINT (X,Y)	-0.22377	0.09291	
0.250	-0.10393	0.21483		-0.10393	0.11856		TAIL POINT (X,Y)	0.25729	0.02288	
0.275	-0.09174	0.22065		-0.09174	0.12030					
0.300	-0.07956	0.22560		-0.07956	0.12167					
0.325	-0.06738	0.22967		-0.06738	0.12267					
0.350	-0.05520	0.23290		-0.05520	0.12328					
0.375	-0.04301	0.23532		-0.04301	0.12352					
0.400	-0.03083	0.23699		-0.03083	0.12339					
0.425	-0.01865	0.23796		-0.01865	0.12288					
0.450	-0.00647	0.23826		-0.00647	0.12199					
0.475	0.00572	0.23792		0.00572	0.12073					
0.500	0.01790	0.23693		0.01790	0.11908					
0.525	0.03008	0.23528		0.03008	0.11706					
0.550	0.04226	0.23295		0.04226	0.11465					
0.575	0.05445	0.22995		0.05445	0.11186					
0.600	0.06663	0.22627		0.06663	0.10868					
0.625	0.07881	0.22188		0.07881	0.10511					
0.650	0.09099	0.21678		0.09099	0.10114					
0.675	0.10318	0.21093		0.10318	0.09678					
0.700	0.11536	0.20432		0.11536	0.09202					
0.725	0.12754	0.19691		0.12754	0.08685					
0.750	0.13972	0.18867		0.13972	0.08125					
0.775	0.15191	0.17952		0.15191	0.07520					
0.800	0.16409	0.16938		0.16409	0.06880					
0.825	0.17627	0.15828		0.17627	0.06213					
0.850	0.18845	0.14629		0.18845	0.05521					
0.875	0.20064	0.13312		0.20064	0.04806					
0.900	0.21282	0.11816		0.21282	0.04066					
0.910	0.21769	0.11154		0.21769	0.03763					
0.920	0.22257	0.10453		0.22257	0.03456					
0.930	0.22744	0.09715		0.22744	0.03145					
0.940	0.23231	0.08939		0.23231	0.02831					
0.950	0.23718	0.08123		0.23718	0.02513					
0.960	0.24206	0.07269		0.24206	0.02190					
0.970	0.24693	0.06378		0.24693	0.01864	0.01995				
0.980	0.25180	0.05455		0.25180	0.01535	0.02008				
0.990	0.25668	0.04502		0.25668	0.01203	0.02237				
1.000	0.26155	0.03518	0.03228	0.26155	0.00868	0.03228				

EXTERNAL (OUR TITLE - SSME FT FINAL 2B...6-22-87...R.J. :Y... RR BAL. 7/8/87, AJF.
TD 0 .0 REV. 0 PART NO. EMD NO. DATE 08/19/87 TIME 11:49:52 CYLINDRICAL
SUBTITLE 1/4 TIP HOT RADIUS = 4.91875 COLD RADIUS = 4.89990 THERMAL SHRINK FACTOR = 1.00000

PRETWIST NOT USED FOR TD PRINTOUT.

PCT X	X TOP	Y TOP	(CIRCLE)	X BOT	Y BOT	(CIRCLE)				
0.0	-0.23546	0.16142	0.15432	-0.23546	0.14050	0.15432				
0.010	-0.22931	0.17426		-0.22931	0.13291	0.13530				
0.020	-0.22316	0.18488		-0.22316	0.12758	0.12887				
0.030	-0.21701	0.19329		-0.21701	0.12454	0.12503				
0.040	-0.21086	0.20089		-0.21086	0.12275	0.12281				
0.050	-0.20471	0.20795		-0.20471	0.12183					
0.060	-0.19856	0.21455		-0.19856	0.12156					
0.070	-0.19241	0.22074		-0.19241	0.12183		L.E. CIRCLE (X,Y,R)	-0.20299	0.15432	0.03247
0.080	-0.18626	0.22655		-0.18626	0.12257		T.E. CIRCLE (X,Y,R)	0.36579	-0.18023	0.01375
0.090	-0.18011	0.23202		-0.18011	0.12371					
0.100	-0.17396	0.23717		-0.17396	0.12523		L.E. TOP TANG. PT. (X,Y)	-0.23224	0.16841	
0.125	-0.15859	0.24875		-0.15859	0.12975		L.E. BOTTOM TANG. PT. (X,Y)	-0.20772	0.12219	
0.150	-0.14321	0.25865		-0.14321	0.13355		T.E. TOP TANG. PT. (X,Y)	0.37839	-0.17474	
0.175	-0.12784	0.26707		-0.12784	0.13652		T.E. BOTTOM TANG. PT. (X,Y)	0.35421	-0.18764	
0.200	-0.11246	0.27411		-0.11246	0.13865					
0.225	-0.09709	0.27990		-0.09709	0.13994		NOSE POINT (X,Y)	-0.23168	0.13910	
0.250	-0.08171	0.28449		-0.08171	0.14042		TAIL POINT (X,Y)	0.37226	-0.19236	
0.275	-0.06634	0.28795		-0.06634	0.14008					
0.300	-0.05096	0.29032		-0.05096	0.13891		NET CROSS-SECT. AREA (EXCL. COATING)	0.05094		
0.325	-0.03559	0.29164		-0.03559	0.13693					
0.350	-0.02021	0.29194		-0.02021	0.13414		GAGING (X,Y,LAMBDA)	0.15624	0.21610	0.29137
0.375	-0.00484	0.29121		-0.00484	0.13054		GAGING ANGLE (DEG.)	28.124		
0.400	0.01054	0.28946		0.01054	0.12615					
0.425	0.02591	0.28670		0.02591	0.12094		CTR. OF GRAV. (INCL. COATING) (X,Y)	0.09128	0.10577	
0.450	0.04129	0.28290		0.04129	0.11494		RAD. REF. PT. (X,Y)	0.0	0.0	
0.475	0.05666	0.27802		0.05666	0.10814		INLET ANGLE (DEG.)	62.054		
0.500	0.07204	0.27204		0.07204	0.10053		INLET WEDGE ANGLE (DEG.)	72.652		
0.525	0.08741	0.26490		0.08741	0.09213		EXIT ANGLE (DEG.)	28.092		
0.550	0.10279	0.25653		0.10279	0.08293		EXIT WEDGE ANGLE (DEG.)	9.038		
0.575	0.11816	0.24682		0.11816	0.07292		UNCOVERED TURNING ANGLE (DEG.)	23.061		
0.600	0.13354	0.23563		0.13354	0.06211		AXIAL CHORD	0.61500		
0.625	0.14891	0.22282		0.14891	0.05049		ACTUAL CHORD	0.70609		
0.650	0.16429	0.20825		0.16429	0.03806		PITCH	0.61811		
0.675	0.17966	0.19181		0.17966	0.02480		NO. OF FOILS	50		
0.700	0.19504	0.17343		0.19504	0.01071					
0.725	0.21041	0.15304		0.21041	-0.00422					
0.750	0.22579	0.13062		0.22579	-0.02001					
0.775	0.24116	0.10621		0.24116	-0.03666					
0.800	0.25654	0.07990		0.25654	-0.05421					
0.825	0.27191	0.05182		0.27191	-0.07266					
0.850	0.28729	0.02219		0.28729	-0.09203					
0.875	0.30266	-0.00882		0.30266	-0.11236					
0.900	0.31804	-0.04097		0.31804	-0.13367					
0.910	0.32419	-0.05410		0.32419	-0.14245					
0.920	0.33034	-0.06737		0.33034	-0.15141					
0.930	0.33649	-0.08077		0.33649	-0.16053					
0.940	0.34264	-0.09428		0.34264	-0.16979					
0.950	0.34879	-0.10791		0.34879	-0.17921					
0.960	0.35494	-0.12164		0.35494	-0.18878	-0.18867				
0.970	0.36109	-0.13545		0.36109	-0.19848	-0.19315				
0.980	0.36724	-0.14934		0.36724	-0.20829	-0.19390				
0.990	0.37339	-0.16331		0.37339	-0.21814	-0.19169				
1.000	0.37954	-0.17736	-0.18023	0.37954	-0.22789	-0.18023				

NO. 1 COR NTOUR TITLE - SSME FT FINAL 2B...6-22-87...R.J. :Y... RR BAL. 7/8/87, AJF.
TD 0 ,0 REV. 0 PART NO. EMD NO. DAIE 08/19/87 TIME 11:49:52 CYLINDRICAL
SUBTITLE 1/4 TIP HOT RADIUS = 4.91875 COLD RADIUS = 4.89990 THERMAL SHRINK FACTOR = 1.00000

PRETWIST NOT USED FOR TD PRINTOUT.

PCT X	X TOP	Y TOP	(CIRCLE)	X BOT	Y BOT	(CIRCLE)				
0.0	-0.18124	0.17768	0.17365	-0.18124	0.16001	0.17365				
0.010	-0.17715	0.18248		-0.17715	0.16088	0.16509				
0.020	-0.17306	0.18711		-0.17306	0.16176	0.16300				
0.030	-0.16898	0.19154		-0.16898	0.16264	0.16270				
0.040	-0.16439	0.19579		-0.16489	0.16352					
0.050	-0.16081	0.19986		-0.16081	0.16439					
0.060	-0.15672	0.20376		-0.15672	0.16524					
0.070	-0.15264	0.20750		-0.15264	0.16606		L.E. CIRCLE (X,Y,R)	-0.17021	0.17365	0.01103
0.080	-0.14855	0.21109		-0.14855	0.16684		T.E. CIRCLE (X,Y,R)	0.21441	0.05951	0.01291
0.090	-0.14447	0.21452		-0.14447	0.16759					
0.100	-0.14038	0.21781		-0.14038	0.16829		L.E. TOP TANG. PT. (X,Y)	-0.17860	0.18081	
0.125	-0.13017	0.22542		-0.13017	0.16985		L.E. BOTTOM TANG. PT. (X,Y)	-0.16787	0.16288	
0.150	-0.11995	0.23220		-0.11995	0.17119		T.E. TOP TANG. PT. (X,Y)	0.22602	0.06516	
0.175	-0.10974	0.23821		-0.10974	0.17233		T.E. BOTTOM TANG. PT. (X,Y)	0.20615	0.04958	
0.200	-0.09952	0.24347		-0.09952	0.17323					
0.225	-0.08931	0.24803		-0.08931	0.17383		NOSE POINT (X,Y)	-0.17967	0.16799	
0.250	-0.07910	0.25190		-0.07910	0.17405		TAIL POINT (X,Y)	0.22238	0.04934	
0.275	-0.06888	0.25507		-0.06888	0.17394					
0.300	-0.05867	0.25759		-0.05867	0.17351					
0.325	-0.04845	0.25944		-0.04845	0.17277					
0.350	-0.03824	0.26066		-0.03824	0.17169					
0.375	-0.02803	0.26127		-0.02803	0.17029					
0.400	-0.01781	0.26130		-0.01781	0.16856					
0.425	-0.00760	0.26080		-0.00760	0.16650					
0.450	0.00262	0.25976		0.00262	0.16412					
0.475	0.01283	0.25822		0.01283	0.16142					
0.500	0.02304	0.25616		0.02304	0.15837					
0.525	0.03326	0.25356		0.03326	0.15501					
0.550	0.04347	0.25042		0.04347	0.15131					
0.575	0.05369	0.24674		0.05369	0.14729					
0.600	0.06390	0.24249		0.06390	0.14294					
0.625	0.07411	0.23766		0.07411	0.13825					
0.650	0.08433	0.23223		0.08433	0.13323					
0.675	0.09454	0.22616		0.09454	0.12788					
0.700	0.10476	0.21942		0.10476	0.12219					
0.725	0.11497	0.21196		0.11497	0.11617					
0.750	0.12518	0.20374		0.12518	0.10979					
0.775	0.13540	0.19468		0.13540	0.10306					
0.800	0.14561	0.18471		0.14561	0.09603					
0.825	0.15583	0.17385		0.15583	0.08874					
0.850	0.16604	0.16212		0.16604	0.08123					
0.875	0.17625	0.14940		0.17625	0.07350					
0.900	0.18647	0.13528		0.18647	0.06554					
0.910	0.19055	0.12917		0.19055	0.06230					
0.920	0.19464	0.12279		0.19464	0.05901					
0.930	0.19872	0.11614		0.19872	0.05570					
0.940	0.20281	0.10922		0.20281	0.05235					
0.950	0.20690	0.10204		0.20690	0.04896	0.04900				
0.960	0.21098	0.09458		0.21098	0.04554	0.04706				
0.970	0.21507	0.08688		0.21507	0.04208	0.04661				
0.980	0.21915	0.07895		0.21915	0.03860	0.04750				
0.990	0.22324	0.07082		0.22324	0.03509	0.05008				
1.000	0.22732	0.06248	0.05951	0.22732	0.03154	0.05951				

EXTERNAL (DUR TITLE - SSME FT FINAL 2B...6-22-87...R.J. .Y... RR BAL. 7/8/87, AJF.
TD 0 .0 REV. 0 PART NO. EMD NO. DATE 08/19/87 TIME 11:49:52 CYLINDRICAL
SUBTITLE TIP HOT RADIUS = 5.18500 COLD RADIUS = 5.16387 THERMAL SHRINK FACTOR = 1.00000

PRETHIST NOT USED FOR TD PRINTOUT.

PCT X	X TOP	Y TOP	(CIRCLE)	X BOT	Y BOT	(CIRCLE)				
0.0	-0.18035	0.26134	0.25452	-0.18035	0.24565	0.25452				
0.010	-0.17515	0.27018		-0.17515	0.23886	0.23902				
0.020	-0.16995	0.27736		-0.16995	0.23374					
0.030	-0.16475	0.28286		-0.16475	0.23029					
0.040	-0.15955	0.28746		-0.15955	0.22775					
0.050	-0.15435	0.29144		-0.15435	0.22582					
0.060	-0.14915	0.29497		-0.14915	0.22434					
0.070	-0.14395	0.29814		-0.14395	0.22323		L.E. CIRCLE (X,Y,R)	-0.15466	0.25452	0.02569
0.080	-0.13875	0.30101		-0.13875	0.22243		T.E. CIRCLE (X,Y,R)	0.32715	-0.16577	0.01250
0.090	-0.13355	0.30360		-0.13355	0.22189					
0.100	-0.12835	0.30595		-0.12835	0.22159		L.E. TOP TANG. PT. (X,Y)	-0.17653	0.26799	
0.125	-0.11535	0.31083		-0.11535	0.22080		L.E. BOTTOM TANG. PT. (X,Y)	-0.17297	0.23650	
0.150	-0.10235	0.31448		-0.10235	0.21930		T.E. TOP TANG. PT. (X,Y)	0.33861	-0.16078	
0.175	-0.08935	0.31705		-0.08935	0.21709		T.E. BOTTOM TANG. PT. (X,Y)	0.31663	-0.17251	
0.200	-0.07635	0.31863		-0.07635	0.21417					
0.225	-0.06335	0.31933		-0.06335	0.21053		NOSE POINT (X,Y)	-0.18019	0.25163	
0.250	-0.05035	0.31918		-0.05035	0.20618		TAIL POINT (X,Y)	0.33304	-0.17680	
0.275	-0.03735	0.31824		-0.03735	0.20113					
0.300	-0.02435	0.31652		-0.02435	0.19536		NET CROSS-SECT. AREA (EXCL. COATING)	0.04103		
0.325	-0.01135	0.31406		-0.01135	0.18889					
0.350	0.00165	0.31086		0.00165	0.18173		GAGING (X,Y,LAMBDA)	0.11435	0.24860	0.30616
0.375	0.01465	0.30691		0.01465	0.17388		GAGING ANGLE (DEG.)	28.027		
0.400	0.02765	0.30222		0.02765	0.16535					
0.425	0.04065	0.29674		0.04065	0.15615		CTR. OF GRAV. (INCL. COATING) (X,Y)	0.10333	0.12832	
0.450	0.05365	0.29047		0.05365	0.14630		RAD. REF. PT. (X,Y)	0.0	0.0	
0.475	0.06665	0.28334		0.06665	0.13579		INLET ANGLE (DEG.)	83.551		
0.500	0.07965	0.27530		0.07965	0.12465		INLET WEDGE ANGLE (DEG.)	103.818		
0.525	0.09265	0.26626		0.09265	0.11289		EXIT ANGLE (DEG.)	28.090		
0.550	0.10565	0.25611		0.10565	0.10052		EXIT WEDGE ANGLE (DEG.)	9.078		
0.575	0.11865	0.24467		0.11865	0.08755		UNCOVERED TURNING ANGLE (DEG.)	24.535		
0.600	0.13165	0.23174		0.13165	0.07401		AXIAL CHORD	0.52000		
0.625	0.14465	0.21708		0.14465	0.05990		ACTUAL CHORD	0.67755		
0.650	0.15765	0.20054		0.15765	0.04524		PITCH	0.65157		
0.675	0.17065	0.18205		0.17065	0.03005		NO. OF FOILS	50		
0.700	0.18365	0.16167		0.18365	0.01434					
0.725	0.19665	0.13955		0.19665	-0.00187					
0.750	0.20965	0.11591		0.20965	-0.01857					
0.775	0.22265	0.09099		0.22265	-0.03574					
0.800	0.23565	0.06502		0.23565	-0.05337					
0.825	0.24865	0.03818		0.24865	-0.07144					
0.850	0.26165	0.01066		0.26165	-0.08993					
0.875	0.27465	-0.01742		0.27465	-0.10883					
0.900	0.28765	-0.04596		0.28765	-0.12814					
0.910	0.29285	-0.05748		0.29285	-0.13596					
0.920	0.29805	-0.06905		0.29805	-0.14385					
0.930	0.30325	-0.08067		0.30325	-0.15180					
0.940	0.30845	-0.09234		0.30845	-0.15981					
0.950	0.31365	-0.10406		0.31365	-0.16787					
0.960	0.31885	-0.11581		0.31885	-0.17599	-0.17511				
0.970	0.32405	-0.12760		0.32405	-0.18417	-0.17788				
0.980	0.32925	-0.13942		0.32925	-0.19241	-0.17809				
0.990	0.33445	-0.15127		0.33445	-0.20069	-0.17592				
1.000	0.33965	-0.16316	-0.16577	0.33965	-0.20903	-0.16577				

NO. 1 CORI NTOUR TITLE - SSME FT FINAL 2B...6-22-87...R.J. .Y... RR BAL. 7/8/87, AJF.
TD 0 .J REV. 0 PART NO. EMD NO. DA:E 08/19/87 TIME 11:49:52 CYLINDRICAL
SUBTITLE TIP HOT RADIUS = 5.18500 COLD RADIUS = 5.16387 THERMAL SHRINK FACTOR = 1.00000

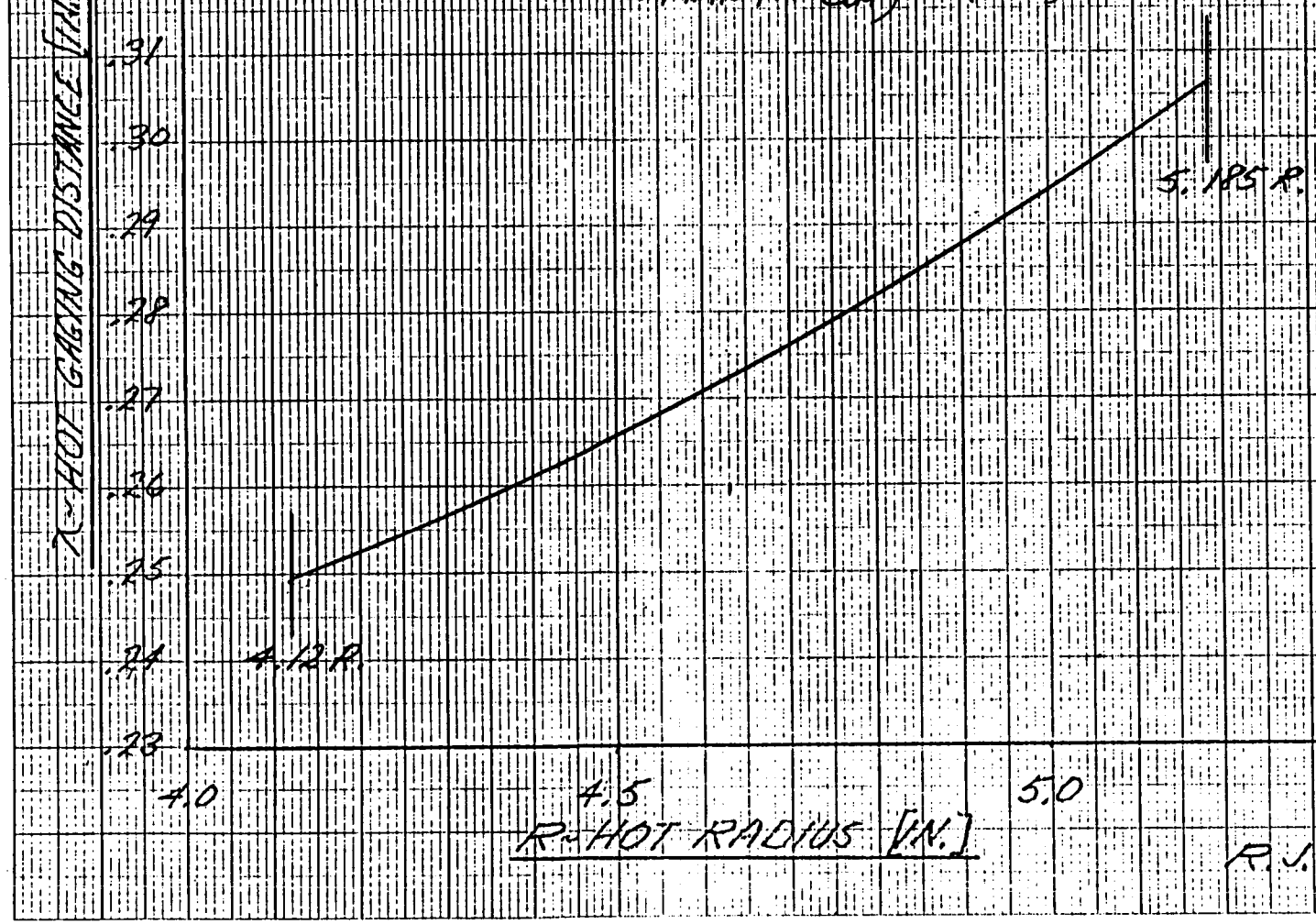
PRETHIST NOT USED FOR TD PRINTOUT.

PCT X	X TOP	Y TOP	(CIRCLE)	X BOT	Y BOT	(CIRCLE)				
0.0	-0.13205	0.27039	0.26332	-0.13205	0.25183	0.26332				
0.010	-0.12883	0.27240	0.27170	-0.12883	0.25150	0.25494				
0.020	-0.12562	0.27425	0.27426	-0.12562	0.25121	0.25238				
0.030	-0.12240	0.27595		-0.12240	0.25096	0.25113				
0.040	-0.11918	0.27749		-0.11918	0.25076					
0.050	-0.11597	0.27889		-0.11597	0.25056					
0.060	-0.11275	0.28017		-0.11275	0.25036					
0.070	-0.10953	0.28135		-0.10953	0.25012		L.E. CIRCLE (X,Y,R)	-0.11953	0.26332	0.01252
0.080	-0.10631	0.28243		-0.10631	0.24984		T.E. CIRCLE (X,Y,R)	0.17714	0.08699	0.01251
0.090	-0.10310	0.28343		-0.10310	0.24951					
0.100	-0.09988	0.28435		-0.09988	0.24911		L.E. TOP TANG. PT. (X,Y)	-0.12554	0.27430	
0.125	-0.09184	0.28629		-0.09184	0.24787		L.E. BOTTOM TANG. PT. (X,Y)	-0.12033	0.25083	
0.150	-0.08380	0.28776		-0.08380	0.24637		T.E. TOP TANG. PT. (X,Y)	0.18822	0.09279	
0.175	-0.07575	0.28877		-0.07575	0.24465		T.E. BOTTOM TANG. PT. (X,Y)	0.16785	0.07862	
0.200	-0.06771	0.28936		-0.06771	0.24271					
0.225	-0.05967	0.28958		-0.05967	0.24053		NOSE POINT (X,Y)	-0.13175	0.26060	
0.250	-0.05163	0.28944		-0.05163	0.23807		TAIL POINT (X,Y)	0.18429	0.07672	
0.275	-0.04358	0.28894		-0.04358	0.23537					
0.300	-0.03554	0.28808		-0.03554	0.23242					
0.325	-0.02750	0.28688		-0.02750	0.22925					
0.350	-0.01946	0.28536		-0.01946	0.22583					
0.375	-0.01141	0.28351		-0.01141	0.22217					
0.400	-0.00337	0.28135		-0.00337	0.21825					
0.425	0.00467	0.27887		0.00467	0.21408					
0.450	0.01271	0.27606		0.01271	0.20968					
0.475	0.02076	0.27292		0.02076	0.20503					
0.500	0.02880	0.26945		0.02880	0.20013					
0.525	0.03684	0.26562		0.03684	0.19500					
0.550	0.04488	0.26144		0.04488	0.18962					
0.575	0.05293	0.25689		0.05293	0.18400					
0.600	0.06097	0.25194		0.06097	0.17814					
0.625	0.06901	0.24658		0.06901	0.17205					
0.650	0.07705	0.24077		0.07705	0.16572					
0.675	0.08510	0.23448		0.08510	0.15915					
0.700	0.09314	0.22765		0.09314	0.15236					
0.725	0.10118	0.22023		0.10118	0.14534					
0.750	0.10922	0.21214		0.10922	0.13809					
0.775	0.11727	0.20332		0.11727	0.13061					
0.800	0.12531	0.19373		0.12531	0.12291					
0.825	0.13335	0.18334		0.13335	0.11499					
0.850	0.14139	0.17214		0.14139	0.10686					
0.875	0.14944	0.16016		0.14944	0.09851					
0.900	0.15748	0.14742		0.15748	0.08995					
0.910	0.16070	0.14212		0.16070	0.08647					
0.920	0.16391	0.13672		0.16391	0.08296					
0.930	0.16713	0.13121		0.16713	0.07941					
0.940	0.17035	0.12559		0.17035	0.07582	0.07648				
0.950	0.17356	0.11989		0.17356	0.07221	0.07500				
0.960	0.17678	0.11409		0.17678	0.06856	0.07448				
0.970	0.18000	0.10821		0.18000	0.06489	0.07481				
0.980	0.18322	0.10224		0.18322	0.06118	0.07605				
0.990	0.18643	0.09619		0.18643	0.05744	0.07861				
1.000	0.18965	0.09006	0.08699	0.18965	0.05367	0.08699				

SSME HPFTP SECOND STAGE BLADE
HOT GAGING VS. RADIUS

MEANLINE DESIGN EFFECTIVE GAGE AREA = 14.4982 in²
PHYSICAL GAGE AREAS = 14.5728 in² HOT } WITH FILLET
= 14.4109 in² COLD } RADII (0.045")

AX. GAGE FLOW AREA, IN²	HOT	COLD
REQUIRED	14.6580	14.4956
ACTUAL	14.6580	14.4956



R.J.R. 8/20/87

P824 UTILITY PROGRAM - FLOW AREA CALCULATION

SSME FT FINAL 2B...6-22-87...R.J.ROWEY... RR BAL. 7/8/87, AJF.

HOT TO COLD CONVERSION RADII

HOT	COLD
4.12000	4.11071
4.22650	4.21606
4.33300	4.32127
4.43950	4.42650
4.54600	4.53166
4.65250	4.63684
4.75900	4.74205
4.86550	4.84729
4.97200	4.95257
5.07850	5.05820
5.18500	5.16387

RESTAGGER ANGLE DEGREES = 0.0 RADIANS = 0.0

PLATFORM RADII LE ID = 4.12000 LE OD = 5.18500

TE ID = 4.12000 TE OD = 5.18500

GAGING RADII INNER = 4.12000 OUTER = 5.18500

NUMBER OF BLADES FOR GAGING = 50

STAGGER IN DEGREES IS -3.00 TO 3.00 IN INCREMENTS OF 0.50

IN CLASS IS - 6 TO 6

TOLER = 0.0

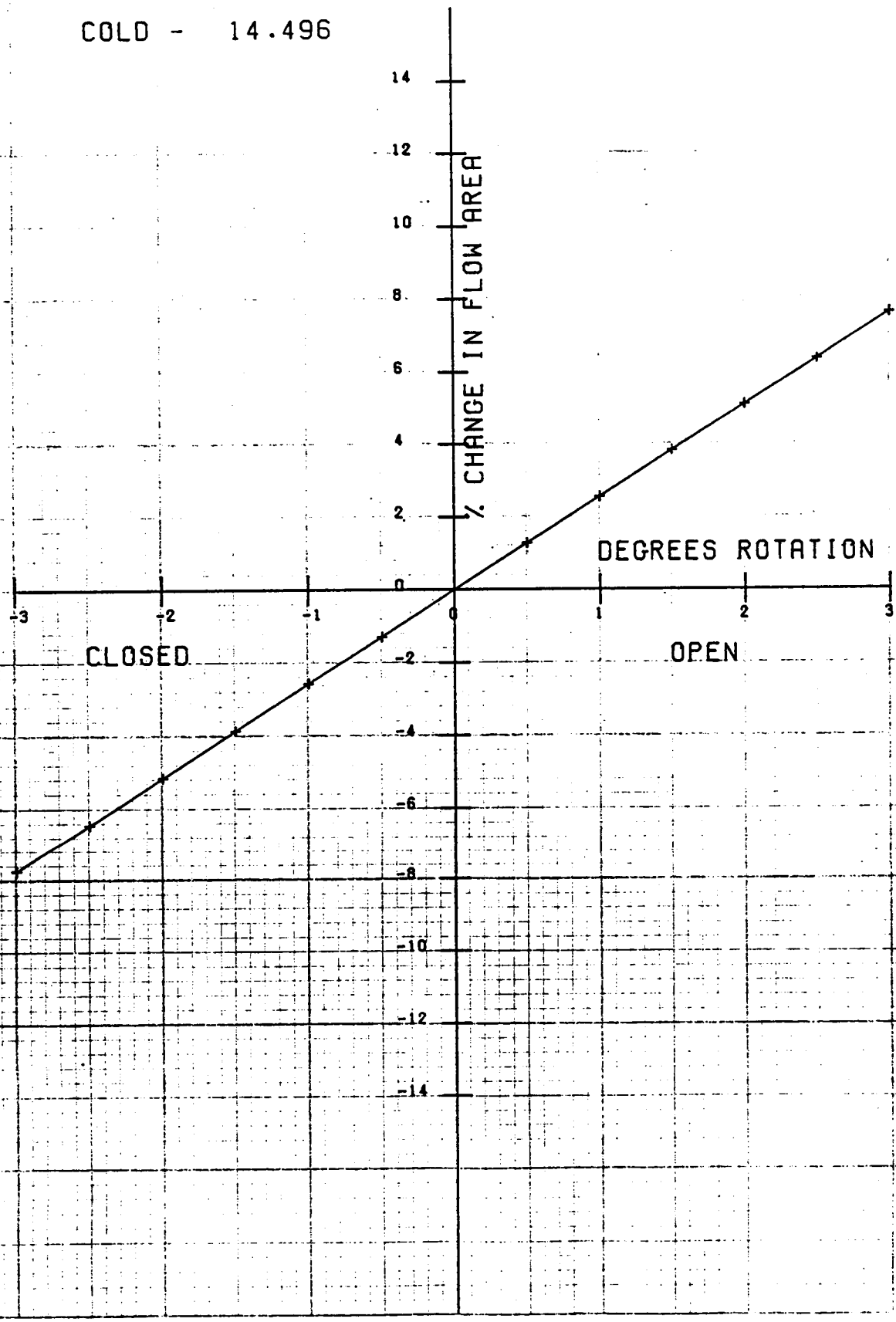
STAGGER (DEGREES)	HOT FLOW (SQ IN)	(CHANGE FLOW AREA	COLD FLOW (SQ IN)
-3.00000	13.51965	-7.76618	
-2.50000	13.71090	-6.46140	
-2.00000	13.90157	-5.16064	
-1.50000	14.09162	-3.86409	
-1.00000	14.28106	-2.57170	
-0.50000	14.46987	-1.28360	
0.0	14.65802	0.0	14.49561 → PHYSICAL GAGE AREA WITHOUT FILLET RADII
0.50000	14.84560	1.27974	
1.00000	15.03241	2.55418	
1.50000	15.21859	3.82437	
2.00000	15.40410	5.08989	
2.50000	15.58890	6.35064	
3.00000	15.77300	7.60662	

SSME FT FINAL 2B...6-22-87...R.J.ROWEY... RR BAL. 7/8/87, AJF

NOMINAL FLOW AREA - SQ. IN.

HOT - 14.658

COLD - 14.496



SSME FT FINAL 2B...6-22-87...R.J.ROMEY... RR BAL. 7/8/87, AJF.
OPERATING CONDITION 1 109 PCT...ADP...R.J.ROMEY...5-15-87...
MAE = 159.5 MXR = 133.6 MXM = 33.4 MXT = 0.0
RPM =36421. MYR = 90.0 MYM = 22.5 MYT = 0.0

NET BENDING

%S	RADIUS	SIG P/A	SHRD P/A	LE	TE	CONV
0	4.1200	36089.	0.	5.	-5.	-0.
10	4.2265	34644.	0.	122.	1073.	-525.
20	4.3330	32924.	0.	178.	1403.	-658.
30	4.4395	30814.	0.	243.	1262.	-632.
40	4.5460	28199.	0.	372.	925.	-576.
50	4.6525	24984.	0.	568.	621.	-593.
60	4.7590	21127.	0.	773.	478.	-677.
70	4.8655	16673.	0.	847.	440.	-716.
80	4.9720	11674.	0.	678.	362.	-575.
90	5.0785	6139.	0.	294.	168.	-248.
100	5.1850	0.	0.	0.	0.	-0.

GAS BENDING

%S	RADIUS	XOFF	YOFF	LE	TE	CONV
0	4.1200	0.0	0.0	37276.	35777.	-35423.
10	4.2265	0.0032	0.0100	31963.	29042.	-29672.
20	4.3330	0.0080	0.0193	27325.	23747.	-25301.
30	4.4395	0.0139	0.0281	23191.	19449.	-21506.
40	4.5460	0.0206	0.0367	19370.	15804.	-18062.
50	4.6525	0.0275	0.0455	15691.	12547.	-14652.
60	4.7590	0.0342	0.0545	12024.	9472.	-11245.
70	4.8655	0.0402	0.0638	8287.	6442.	-7704.
80	4.9720	0.0457	0.0731	4604.	3524.	-4222.
90	5.0785	0.0506	0.0822	1464.	1097.	-1320.
100	5.1850	0.0551	0.0910	0.	0.	-0.

SHROUD MISALIGNMENT

%S	RADIUS	AREA	PULL	LE	TE	CONV
0	4.1200	0.1056	523.4	0.	0.	0.
10	4.2265	0.0949	482.2	0.	0.	0.
20	4.3330	0.0853	444.1	0.	0.	0.
30	4.4395	0.0767	410.0	0.	0.	0.
40	4.5460	0.0692	380.2	0.	0.	0.
50	4.6525	0.0629	354.8	0.	0.	0.
60	4.7590	0.0576	333.1	0.	0.	0.
70	4.8655	0.0531	313.6	0.	0.	0.
80	4.9720	0.0489	295.0	0.	0.	0.
90	5.0785	0.0450	275.9	0.	0.	0.
100	5.1850	0.0410	0.0	0.	0.	0.

%S	RADIUS	MXT	MYT	MXG	MYG	THETA N
0	4.1200	-133.6	-90.0	133.6	90.0	-13.40
10	4.2265	-104.5	-78.6	108.2	72.9	-33.54
20	4.3330	-80.9	-64.2	85.5	57.6	-35.14
30	4.4395	-61.6	-48.8	65.5	44.1	-39.57
40	4.5460	-45.4	-34.5	48.1	32.4	-52.89
50	4.6525	-31.7	-22.3	33.4	22.5	83.34
60	4.7590	-20.3	-13.1	21.4	14.4	37.64
70	4.8655	-11.3	-6.7	12.0	8.1	25.83
80	4.9720	-4.9	-2.7	5.3	3.6	25.11
90	5.0785	-1.2	-0.6	1.3	0.9	28.11
100	5.1850	0.0	0.0	0.0	0.0	0.0

SSME FT FINAL 2B...6-22-87...R.J.ROWEY... RR BAL. 7/8/87, AJF.
DENSITY = 0.31200 WEIGHTING RADII INNER = 4.1200 OUTER = 5.1850
SHROUD VOLUME = 0.0 SHROUD THICKNESS = 0.0
SHROUD MISALIGNMENT = 0.0 RADIUS OF SHROUD = 0.0
WEIGHT OF AIRFOIL = 0.02215 WEIGHT OF SHROUD = 0.0
TOTAL WEIGHT = 1.10728 NUMBER OF BLADES = 50

SUMMARY OF SECTION PROPERTIES

%S	RADIUS	AREA	IMIN	IMAX	THETA	XBAR	YBAR
0	4.1200	0.1056	0.6996E-03	0.7045E-02	-14.48	0.0482	0.0374
10	4.2265	0.0949	0.7014E-03	0.6042E-02	-14.49	0.0515	0.0474
20	4.3330	0.0853	0.6711E-03	0.5133E-02	-15.10	0.0562	0.0567
30	4.4395	0.0767	0.6135E-03	0.4332E-02	-16.41	0.0622	0.0655
40	4.5460	0.0692	0.5358E-03	0.3644E-02	-18.48	0.0689	0.0741
50	4.6525	0.0629	0.4465E-03	0.3068E-02	-21.35	0.0758	0.0829
60	4.7590	0.0576	0.3540E-03	0.2598E-02	-24.99	0.0824	0.0919
70	4.8655	0.0531	0.2676E-03	0.2217E-02	-29.20	0.0885	0.1012
80	4.9720	0.0489	0.1935E-03	0.1908E-02	-33.75	0.0939	0.1105
90	5.0785	0.0450	0.1344E-03	0.1652E-02	-38.45	0.0988	0.1196
100	5.1850	0.0410	0.9027E-04	0.1435E-02	-43.12	0.1033	0.1284

%S	RADIUS	K	L	MAX T	AX.WIDTH	C1	C2
0	4.1200	0.0	0.2166E-03	0.2117	0.9000	0.1574	0.1817
10	4.2265	0.0	0.1613E-03	0.2273	0.8620	0.1666	0.1846
20	4.3330	0.0	0.1223E-03	0.2413	0.8240	0.1719	0.1834
30	4.4395	0.0	0.9483E-04	0.2535	0.7860	0.1739	0.1779
40	4.5460	0.0	0.7544E-04	0.2640	0.7480	0.1726	0.1686
50	4.6525	0.0	0.6137E-04	0.2727	0.7100	0.1683	0.1558
60	4.7590	0.0	0.5097E-04	0.2805	0.6720	0.1609	0.1402
70	4.8655	0.0	0.4291E-04	0.2879	0.6340	0.1506	0.1232
80	4.9720	0.0	0.3648E-04	0.2960	0.5960	0.1381	0.1060
90	5.0785	0.0	0.3106E-04	0.3061	0.5580	0.1242	0.0894
100	5.1850	0.0	0.2646E-04	0.3192	0.5200	0.1100	0.0742

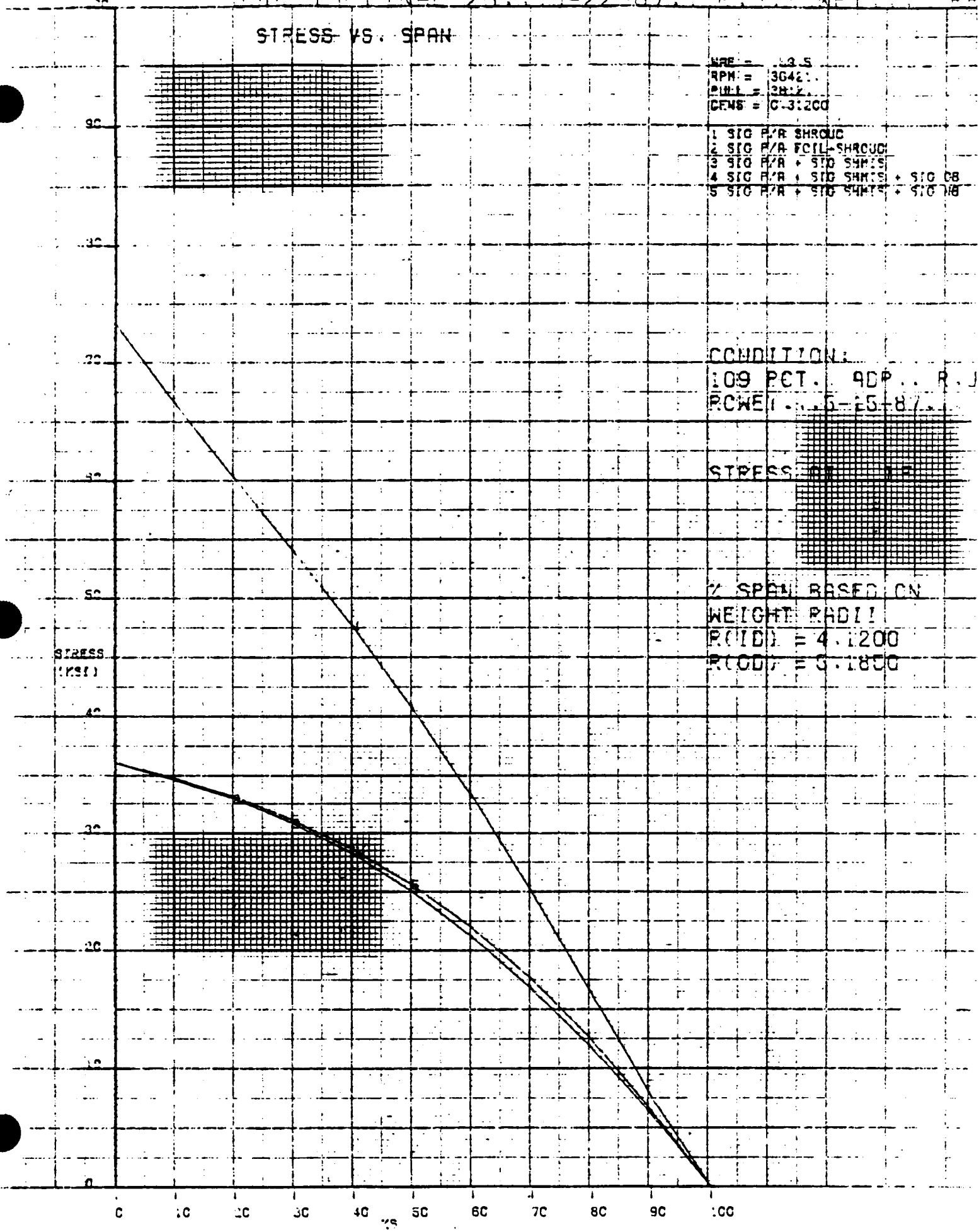
%S	RADIUS	C3	CLE	CTE	C4	ALPHA B	B
0	4.1200	0.1630	0.4061	0.4794	0.0053	73.44	0.9264
10	4.2265	0.1689	0.3805	0.4639	0.0062	73.85	0.8836
20	4.3330	0.1726	0.3581	0.4482	0.0317	73.75	0.8433
30	4.4395	0.1736	0.3383	0.4331	0.0382	73.04	0.8060
40	4.5460	0.1712	0.3203	0.4191	0.0475	71.67	0.7720
50	4.6525	0.1652	0.3042	0.4069	0.0397	69.58	0.7419
60	4.7590	0.1552	0.2905	0.3964	0.0522	66.73	0.7167
70	4.8655	0.1420	0.2801	0.3875	0.0637	63.21	0.6968
80	4.9720	0.1268	0.2737	0.3795	0.0733	59.16	0.6825
90	5.0785	0.1109	0.2719	0.3719	0.0630	54.76	0.6731
100	5.1850	0.0954	0.2745	0.3644	0.0683	50.15	0.6685

P824 UTILITY PROGRAM - STRESS CALCULATION

SSME FT FINAL 2B...6-22-87...R.J.ROMEY... RR BAL. 7/8/87, AJF.
ENGINE OPERATING CONDITION

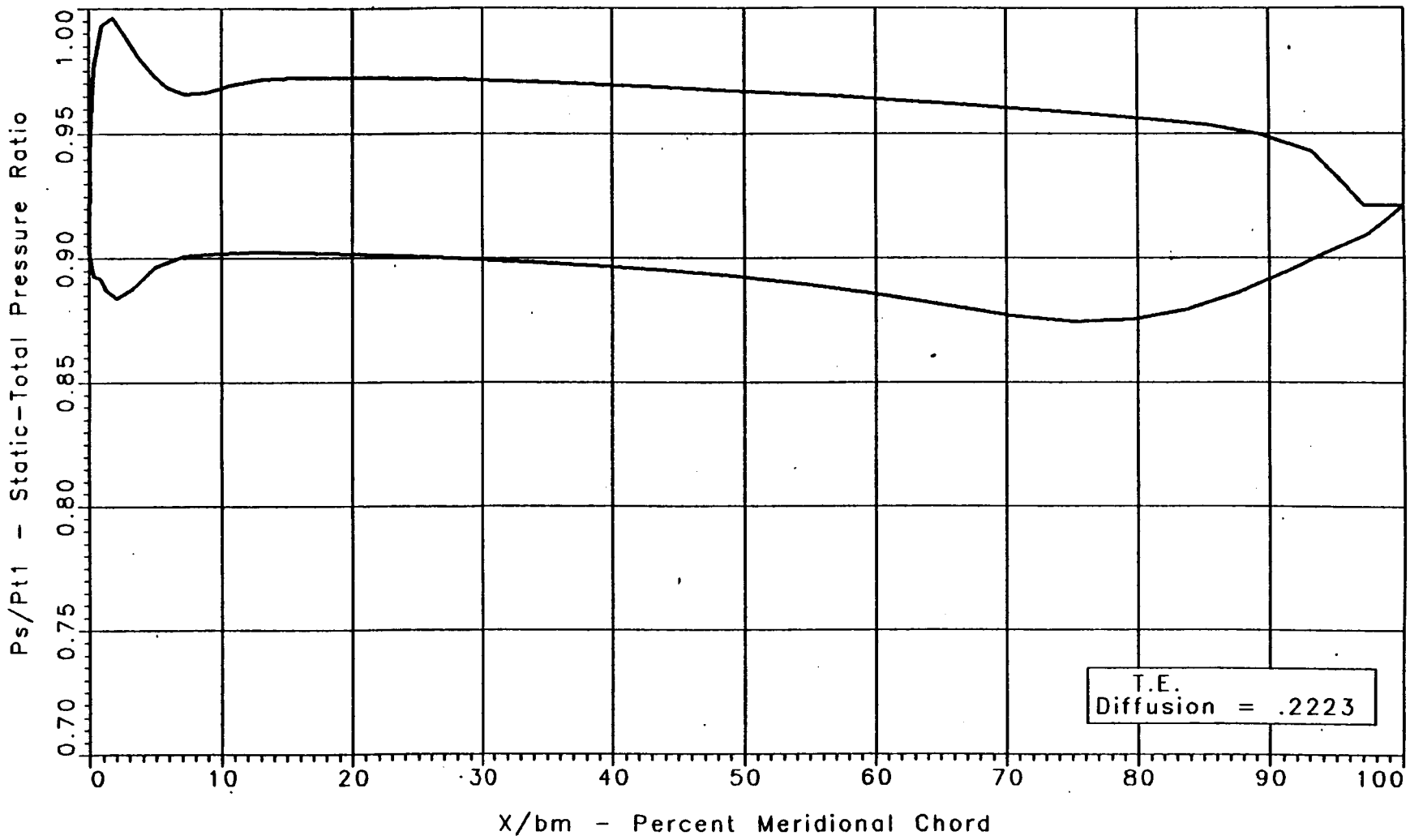
	MAE	RPM	TITLE
1	159.5	36421.	109 PCT...ADP...R.J.ROMEY...5-15-87...

XGBR = 133.60001 XGBM = 33.39999 XGBT = 0.0
YGBR = 90.04201 YGBM = 22.50999 YGBT = 0.0
DENSITY = 0.31200 WEIGHTING RADII INNER = 4.1200 OUTER = 5.1850
SHROUD VOLUME = 0.0 SHROUD THICKNESS = 0.0
SHROUD MISALIGNMENT = 0.0 RADIUS OF SHROUD = 0.0


SSME FT FINAL 2B, 6-22-87, R. L. WEY
STRESS VS. SPAN
RPM = 3642
DENS = 0.31200
1 SIG P/A SHROUD
2 SIG P/A FOIL-SHROUD
3 SIG P/A + SIG SHMIS
4 SIG P/A + SIG SHMIS + SIG GB
5 SIG P/A + SIG SHMIS + SIG NB
CONDITION:
109 PCT. ADP.. R.J
ROWEY...5-25-87..
STRESS
% SPAN BASED ON
WEIGHT RADII
R(ID) = 4.1200
R(OD) = 5.1850
STRESS (KSI)
0
10
20
30
40
50
60
70
80
90
100
%S

PRATT & WHITNEY
SSME ATD Fuel Pump Turbine
3-D Pressure Distribution (V310)
Poisson Generated "C"-Mesh

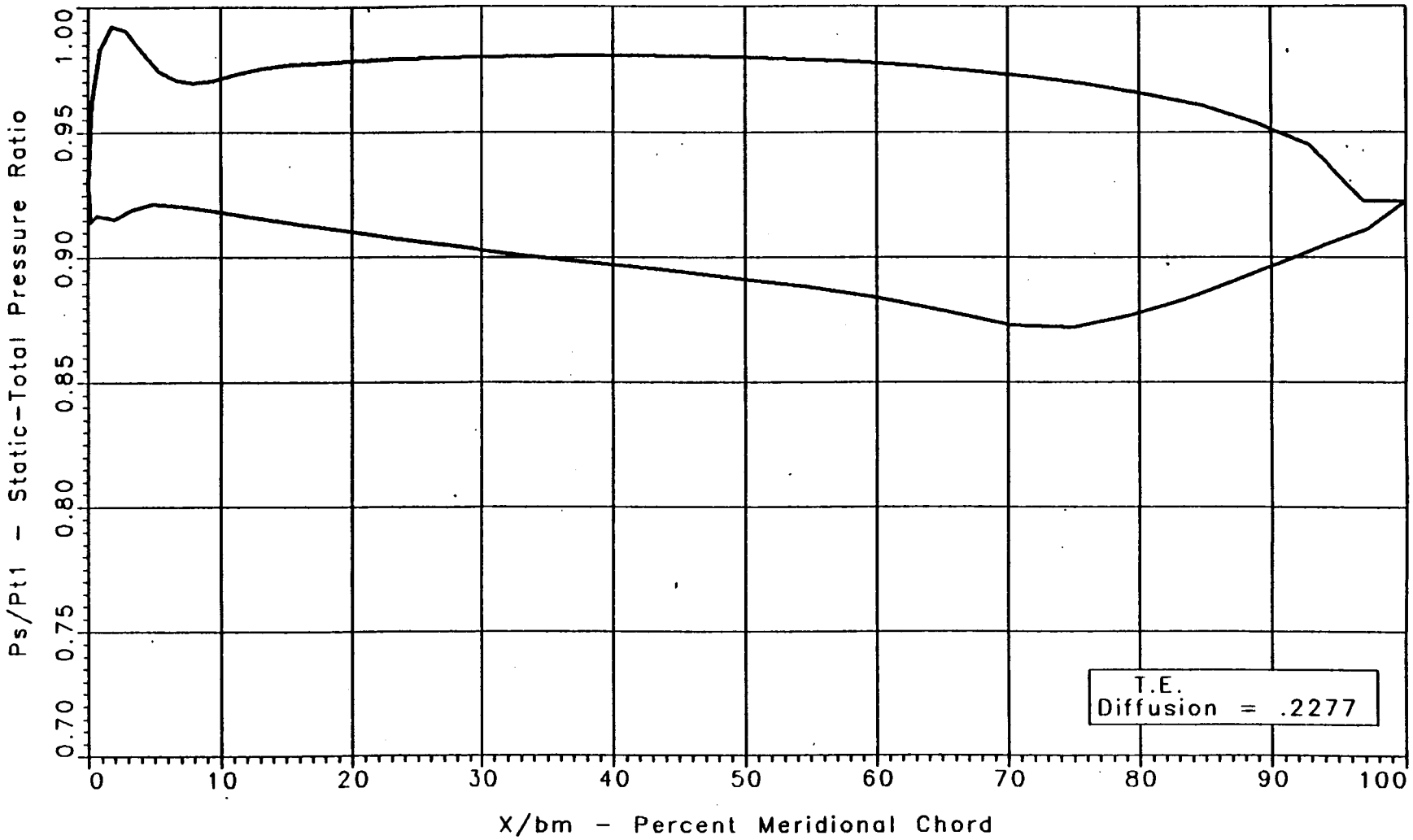
16 Second Stage Blade: 0% Span



08/20/87
DLS

PRATT & WHITNEY
SSME ATD Fuel Pump Turbine
3-D Pressure Distribution (V310)
Poisson Generated "C"-Mesh

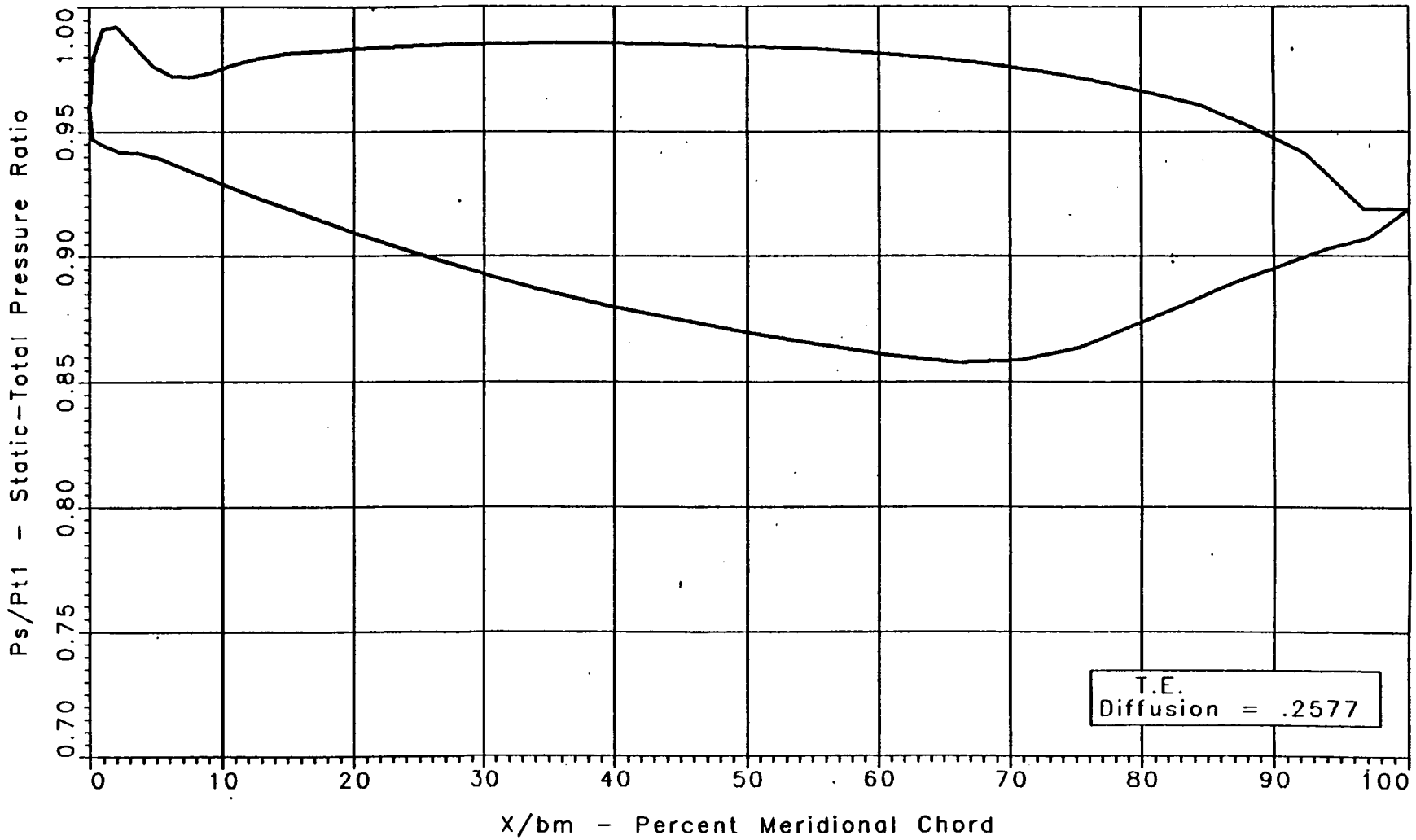
17 Second Stage Blade: 25% Span



08/20/87
DLS

PRATT & WHITNEY
SSME ATD Fuel Pump Turbine
3-D Pressure Distribution (V310)
Poisson Generated "C"-Mesh

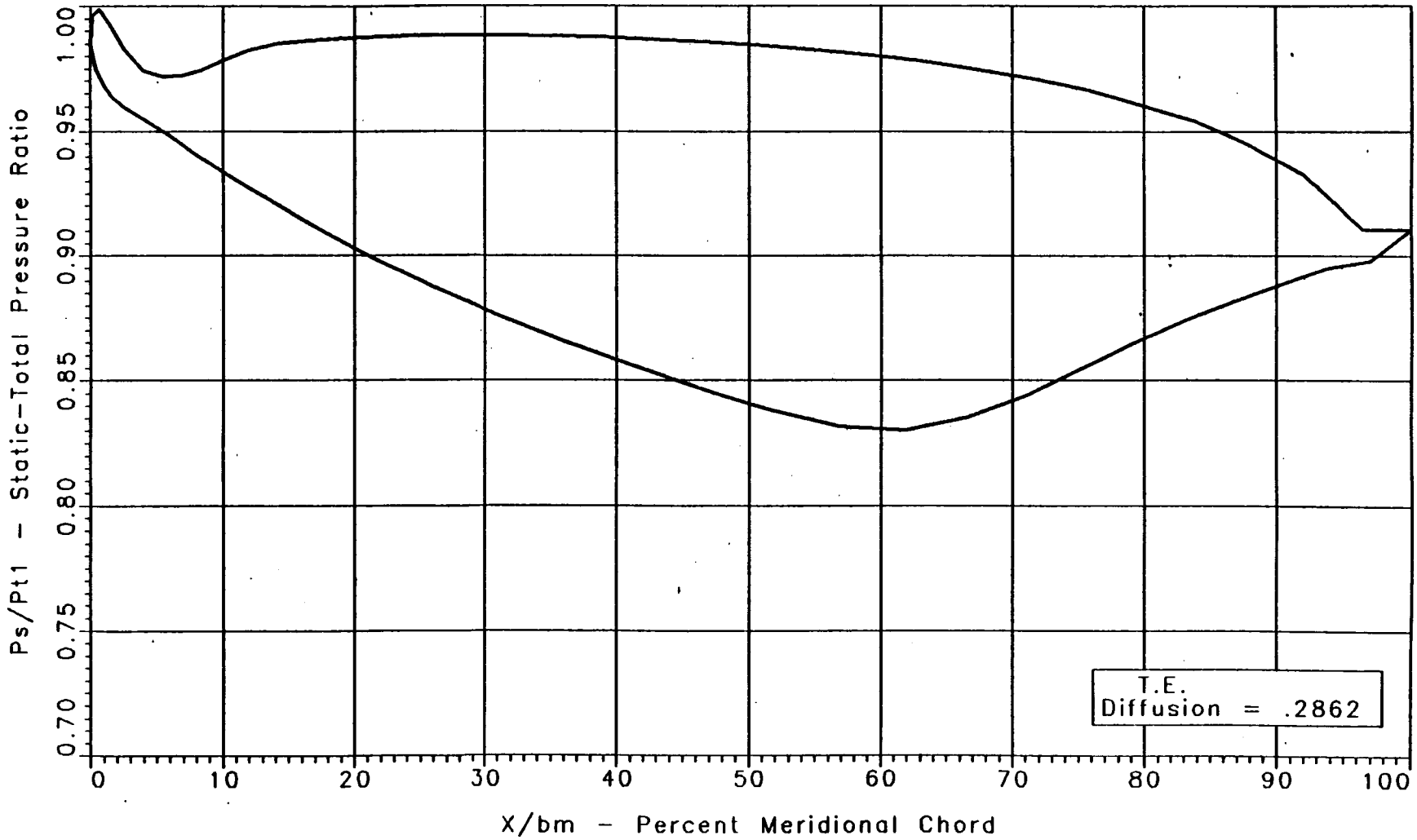
18 Second Stage Blade: 50% Span



08/20/87
DLS

PRATT & WHITNEY
SSME ATD Fuel Pump Turbine
3-D Pressure Distribution (V310)
Poisson Generated "C"-Mesh

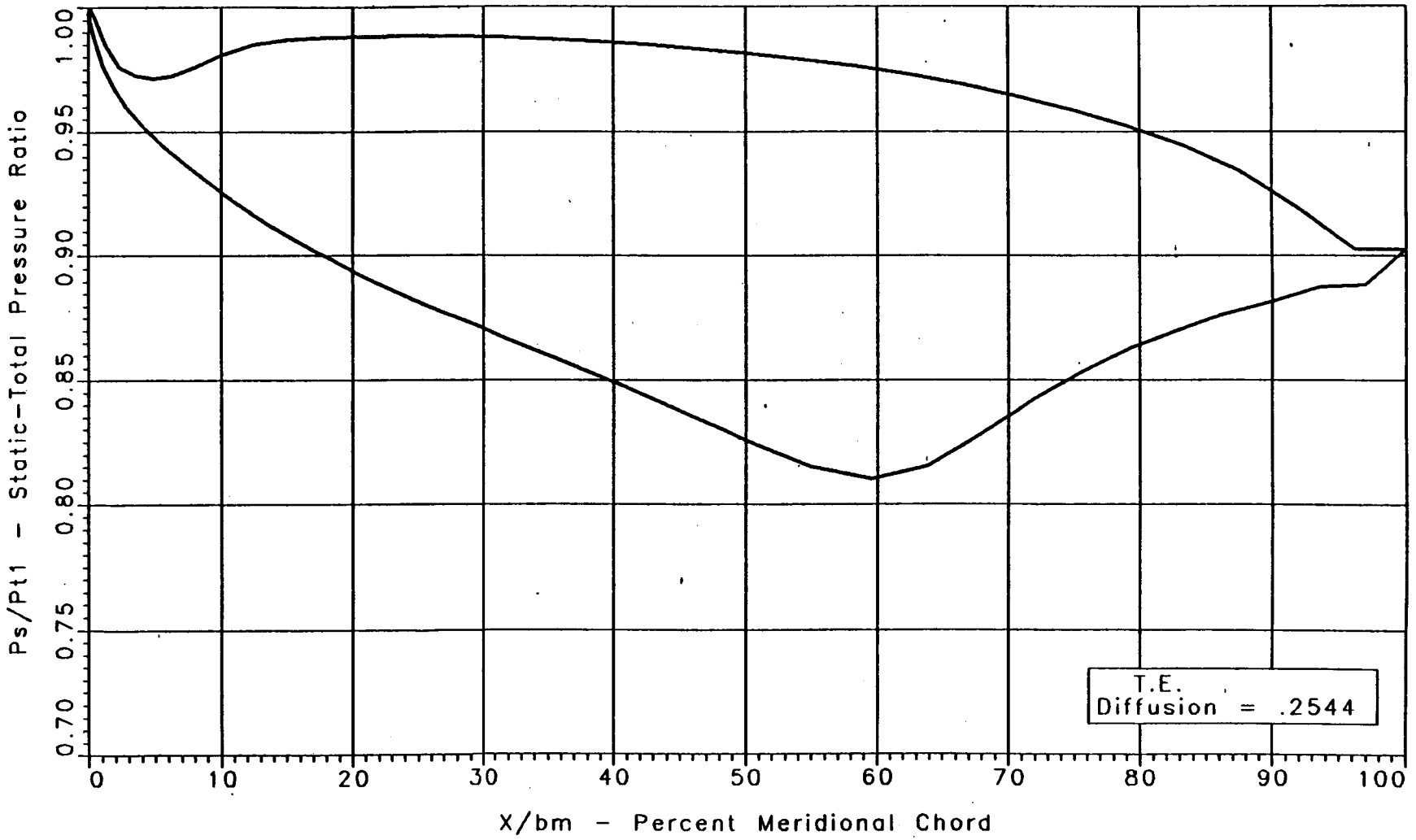
19 Second Stage Blade: 75% Span



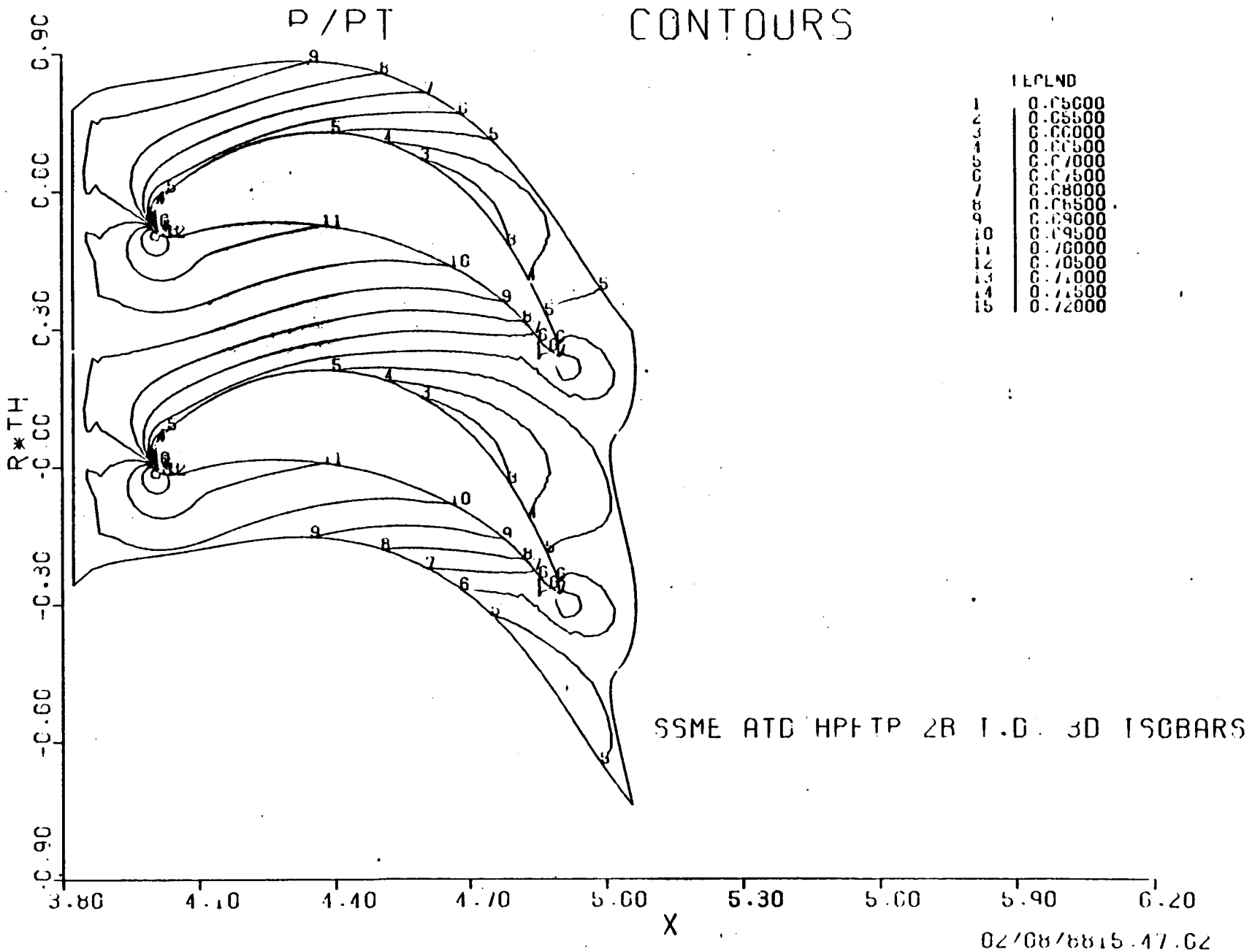
08/20/87
DLS

PRATT & WHITNEY
SSME ATD Fuel Pump Turbine
3-D Pressure Distribution (V310)
Poisson Generated "C"-Mesh

20 Second Stage Blade: 100% Span

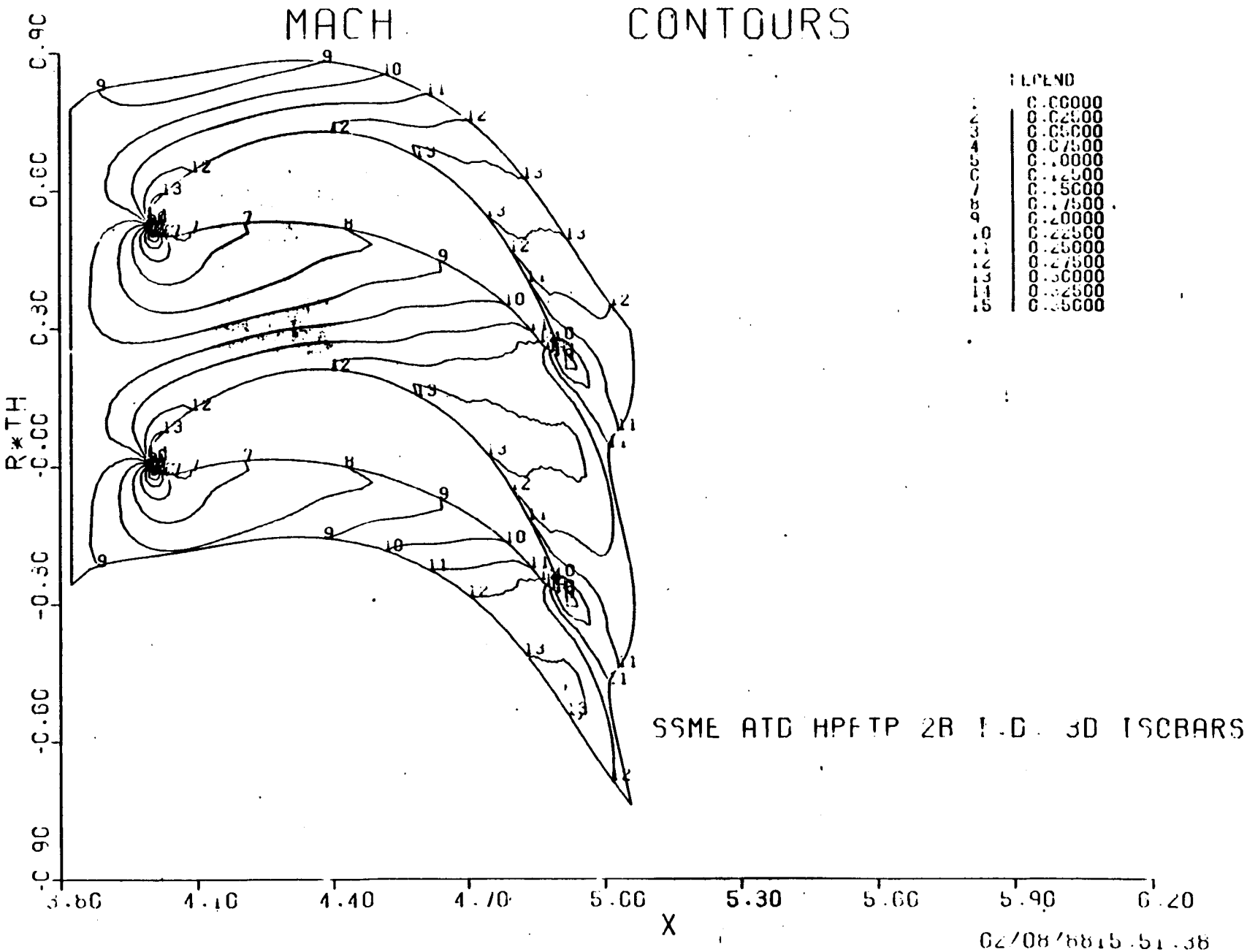


08/20/87
DLS



02/08/88 15.47.02

KSLICE= 1 NI 3D CYLINDRICAL C-GRID INLET STRUT.. R.L. ROWLY. 01-05-88 R



02/08/88 15.51.38

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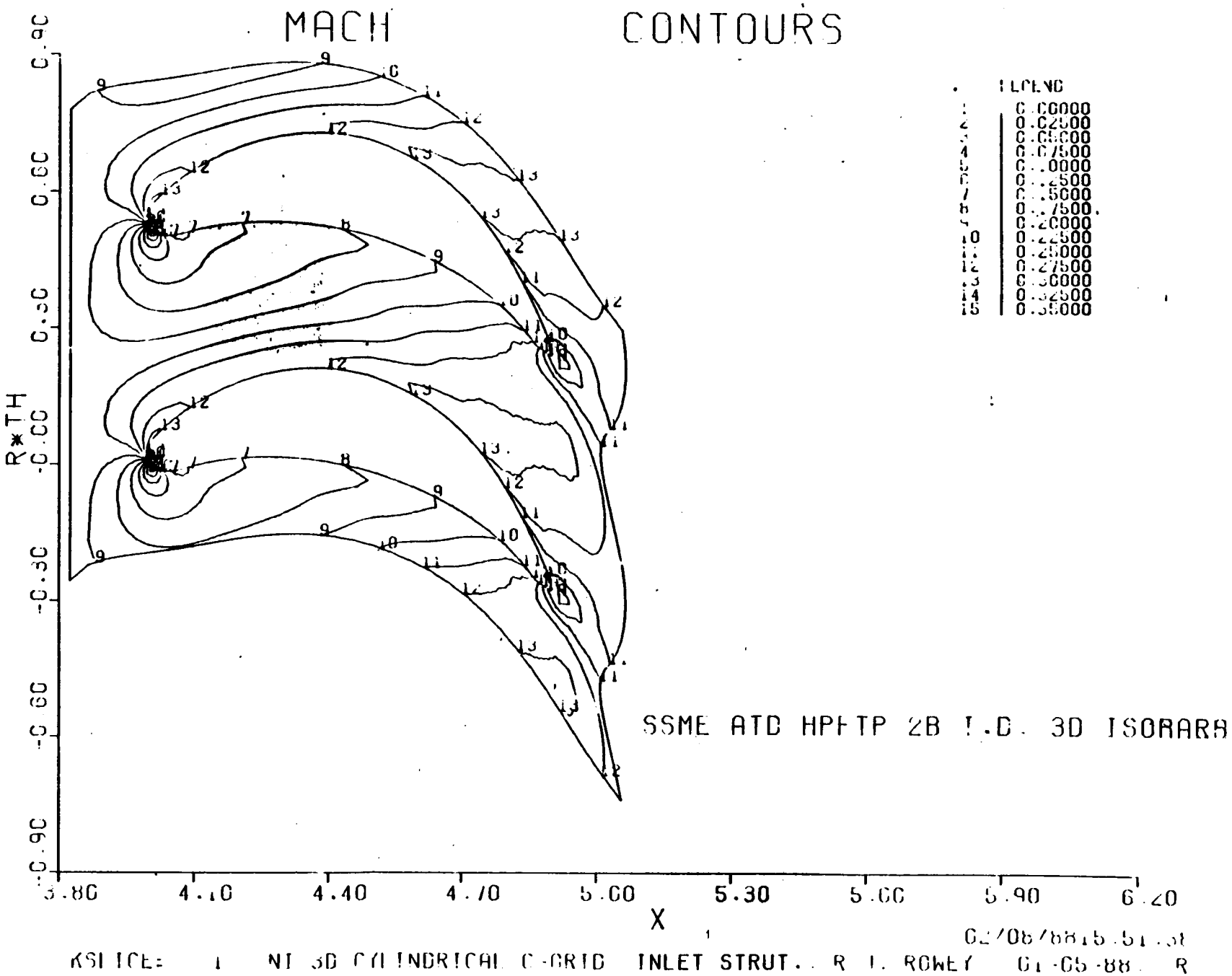

MACH CONTOURS
LEGEND
1 0.00000
2 0.02500
3 0.05000
4 0.07500
5 0.10000
6 0.12500
7 0.15000
8 0.17500
9 0.20000
10 0.22500
11 0.25000
12 0.27500
13 0.30000
14 0.32500
15 0.35000
R*TH
0.90
0.60
0.30
-0.00
-0.30
-0.60
-0.90
3.80
4.10
4.40
4.70
5.00
5.30
5.60
5.90
6.20
X
SSME ATD HPFTP 2B I.D. 3D ISOBARA
KSLICE: 1 NI 3D CYLINDRICAL C-GRID INLET STRUT.. R I. ROWEY 01-05-88 R

U456 — FINITE TRANSITION INTEGRAL BOUNDARY LAYER DECK

DATE 07/28/87 AME 11 57 04

SECOND BLADE R. J. ROWEY 06/11/87 R

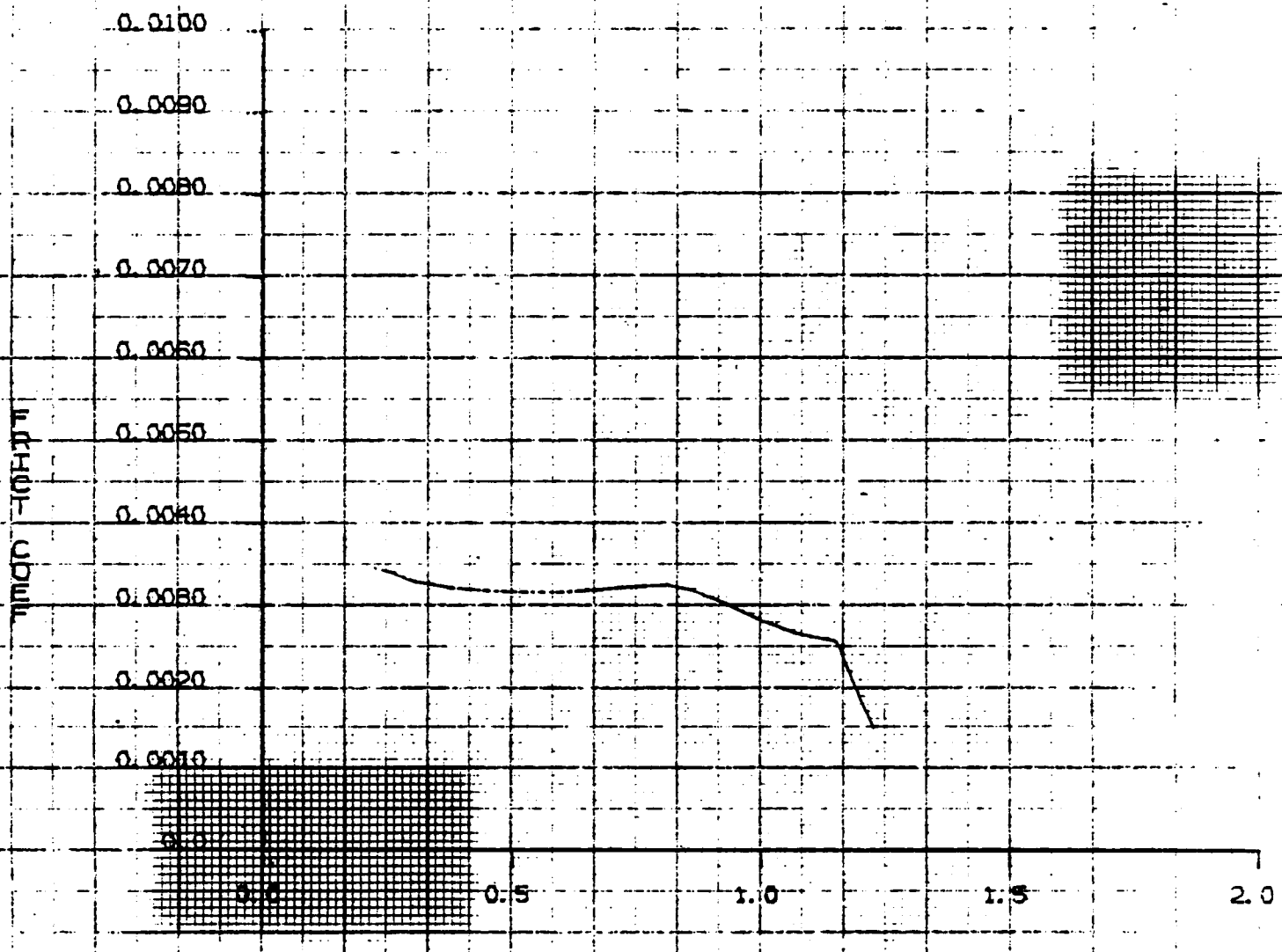
JRFUEL2 U76 RIF= 4.12 RIF= 4.12

4.00% TU

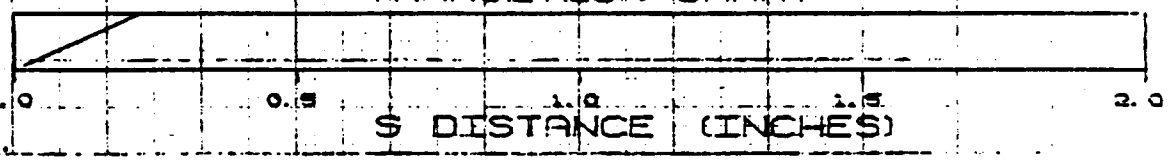
	INLET	EXIT
MACH NO.	0.276	0.379
GAS ANGLES	47.21	27.81

SUCTION SIDE

REF. REYNOLDS NO. 9104505



TRANSITION CHART



U456 - FINITE TRANSITION INTEGRAL BOUNDARY LAYER DECK

DATE 07/28/87 TIME 11:59:51

SECOND BLADE... R. J. ROWEY... 06/11/87... R

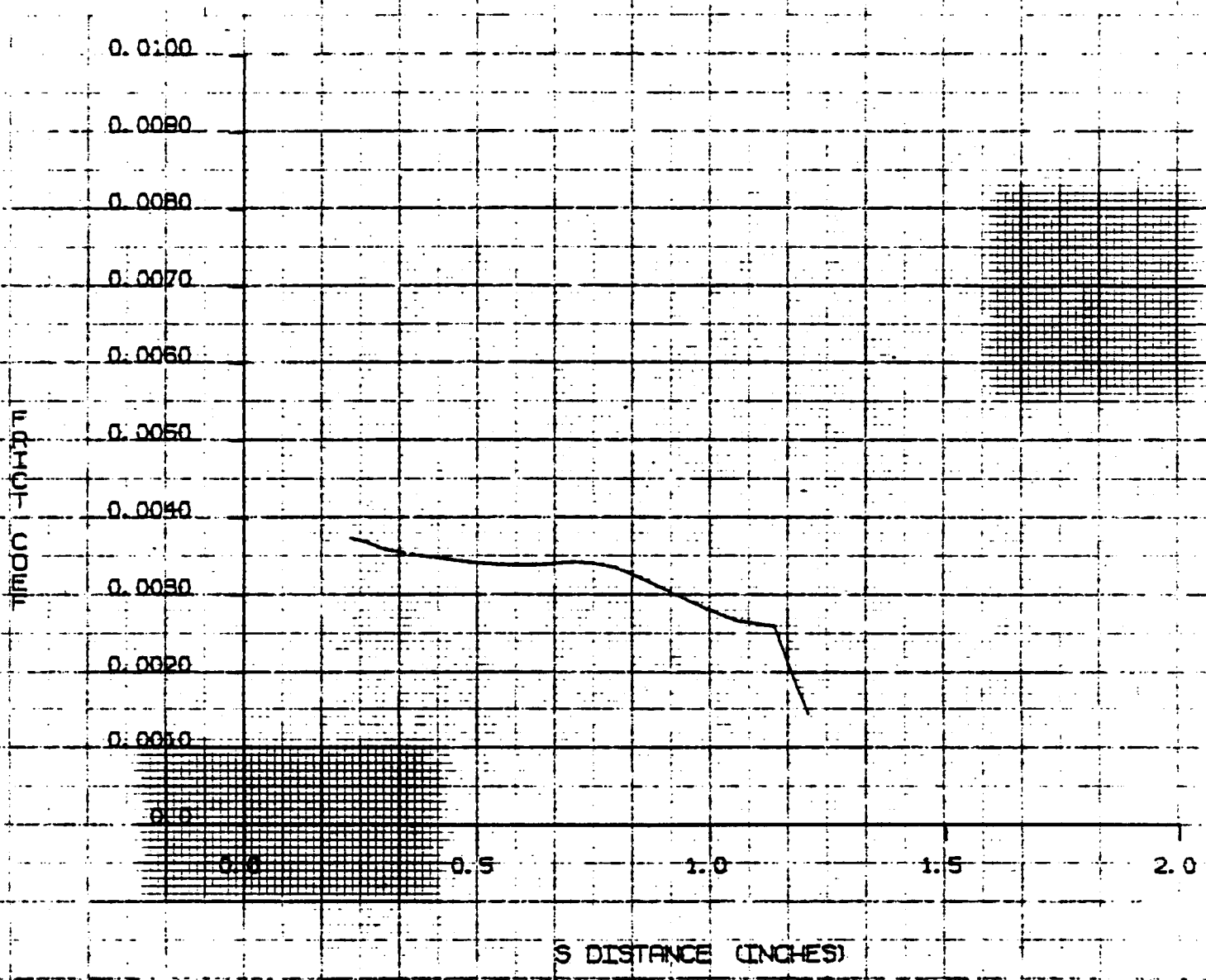
JRFUEL2 U76 RLE= 4.39 RTE= 4.39

4.00% TU

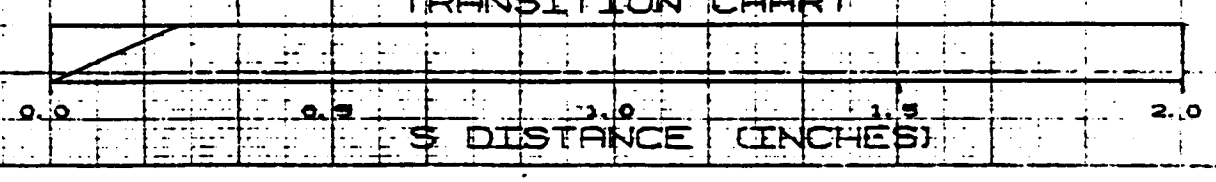
	INLET	EXIT
MACH NO.	0.234	0.372
GAS ANGLES	41.46	26.36

SUCTION SIDE

REF. REYNOLDS NO. 7822771.



TRANSITION CHART



U456 — FINITE TRANSITION INTEGRAL BOUNDARY LAYER DECK

DATE 07/28/87 TIME 12:01:57

SECOND BLADE.. R.J. ROHEY.. 06/11/87.. R

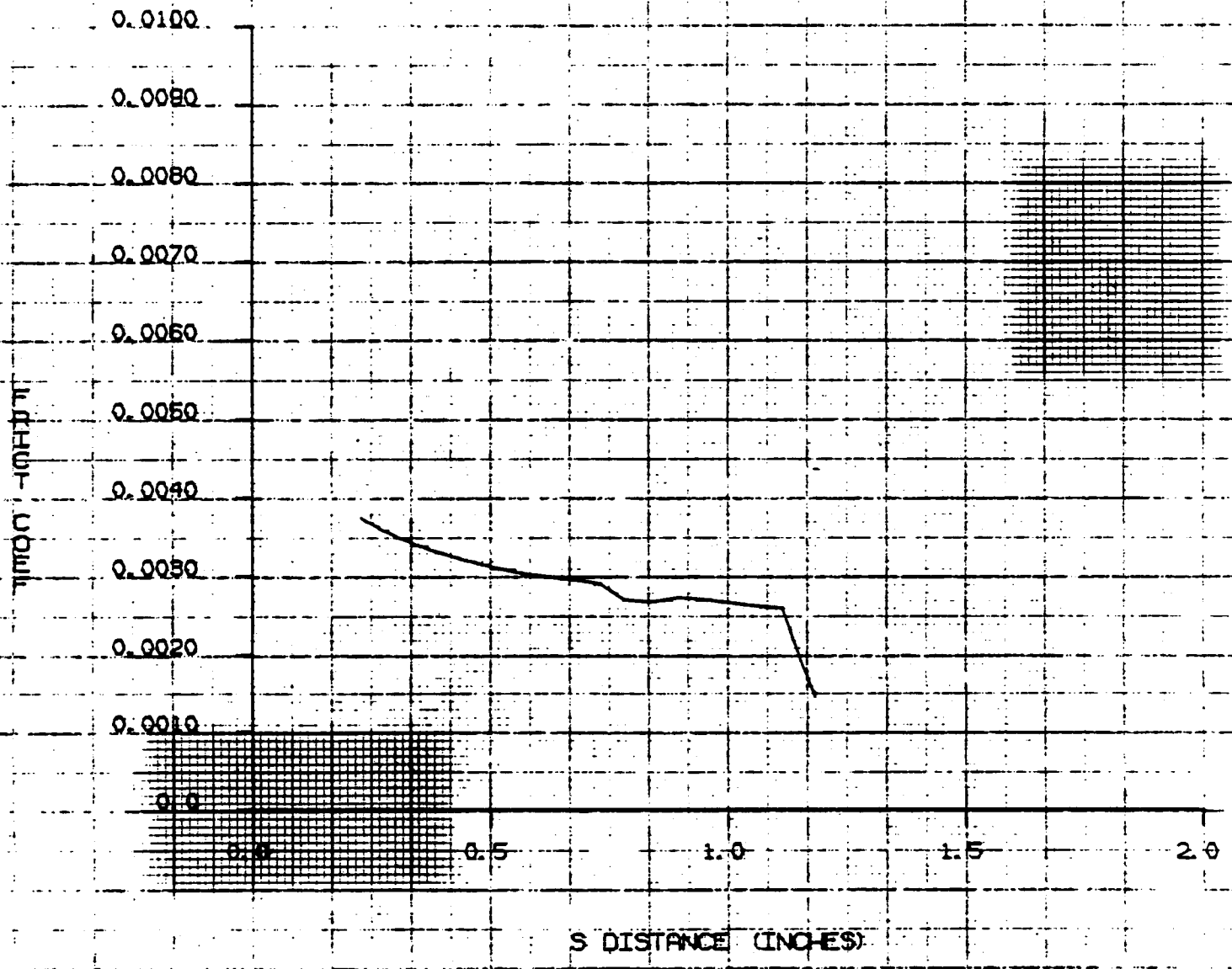
JREVEL2 U76 RUE= 4.66 RTE= 4.66

4.00% TU

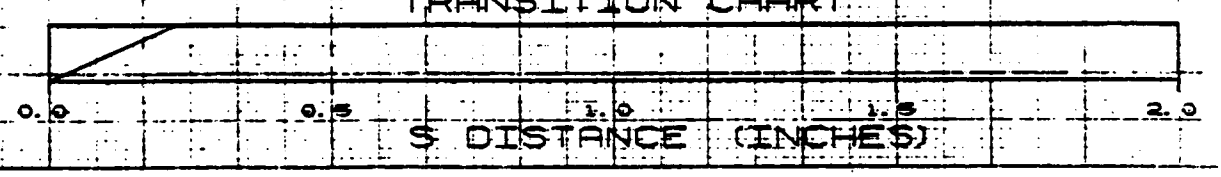
	INLET	EXIT
MACH NO.	0.205	0.384
GAS ANGLES	47.35	27.54

SUCTION SIDE

REF. REYNOLDS NO. 8154124.



TRANSITION CHART



U456 — FINITE TRANSITION INTEGRAL BOUNDARY LAYER DECK

DATE 07/28/87 TIME 12.04.07

SECOND BLADE . . R. J. ROWEY . . 06/11/87 . . R

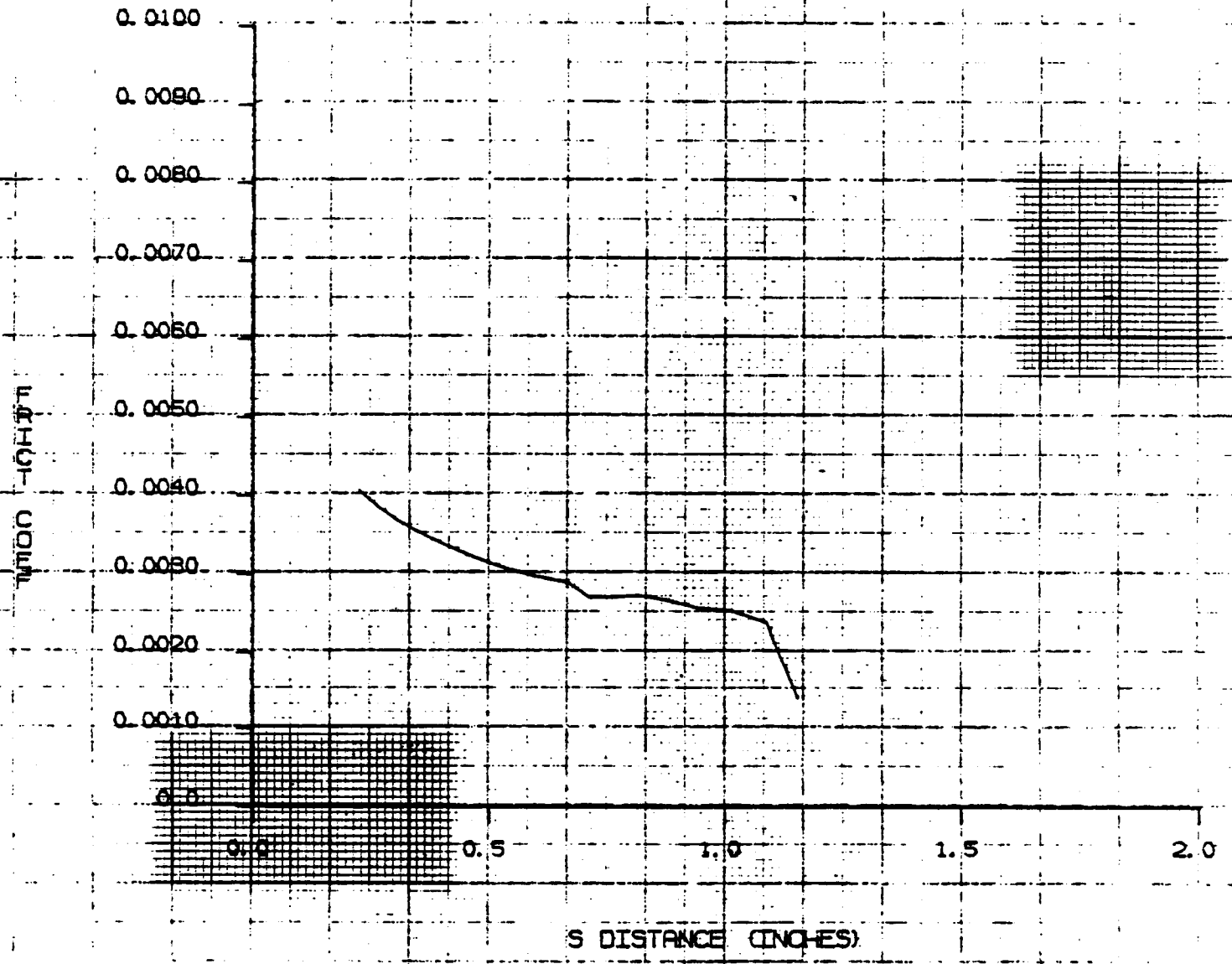
JRFUEL2 U76 RLE= 4.93 RTE= 4.93

4.00% TU

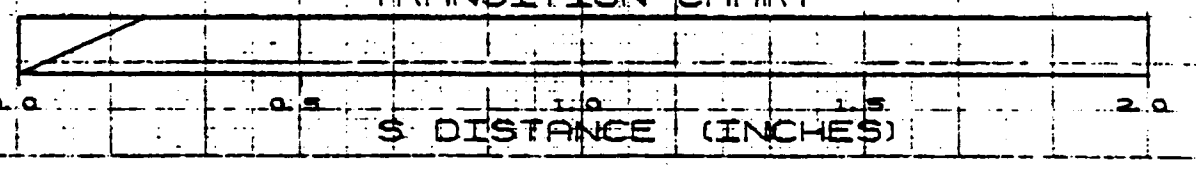
	INLET	EXIT
MACH NO.	0.188	0.406
GAS ANGLES	66.31	28.76

SUCTION SIDE

REF. REYNOLDS NO. 9382554.



TRANSITION CHART



U456 — FINITE TRANSITION INTEGRAL BOUNDARY LAYER DECK

DATE 07/28/87 TIME 12:06:12

SECOND BLADE...R.J. ROWEY...06/11/87...R

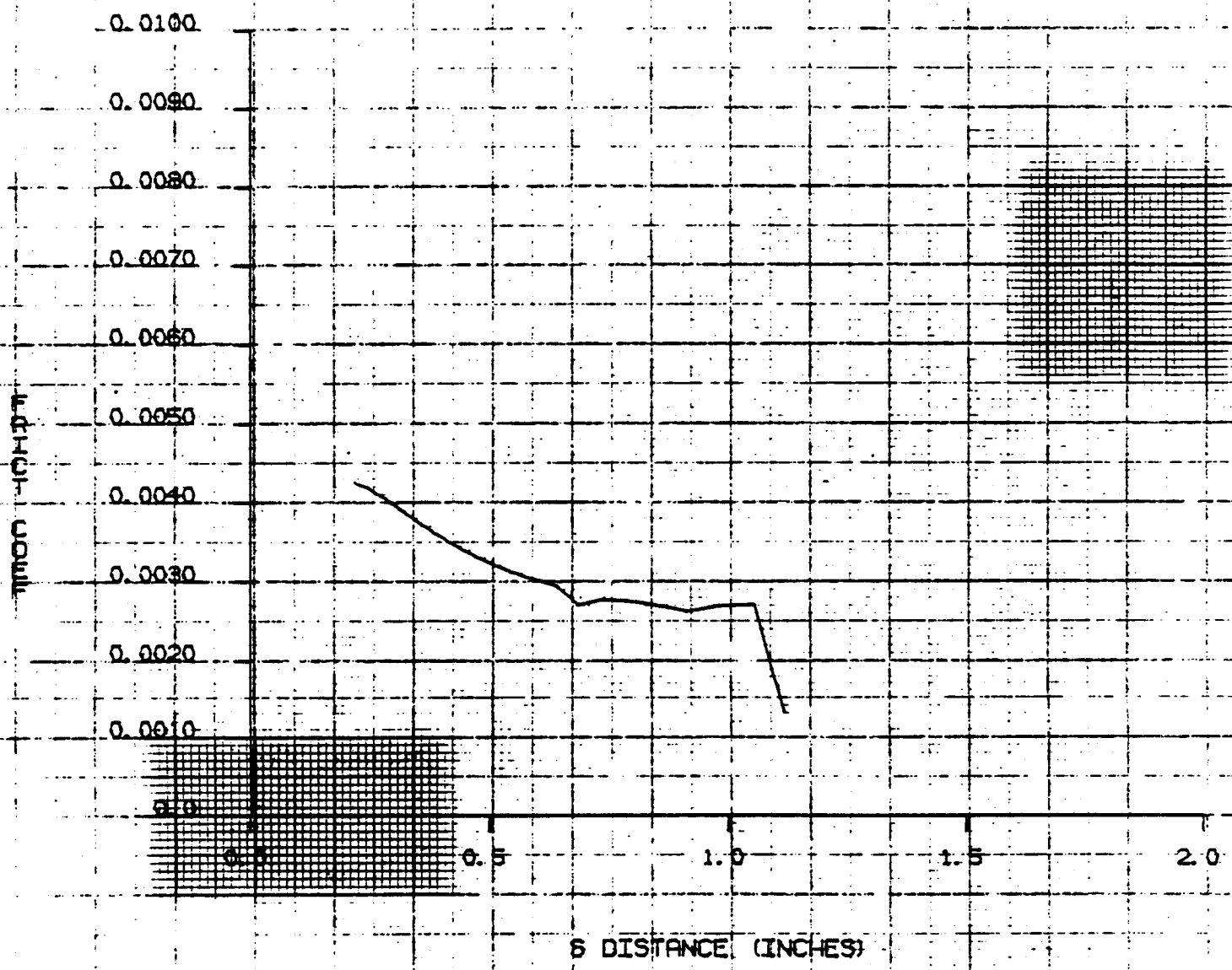
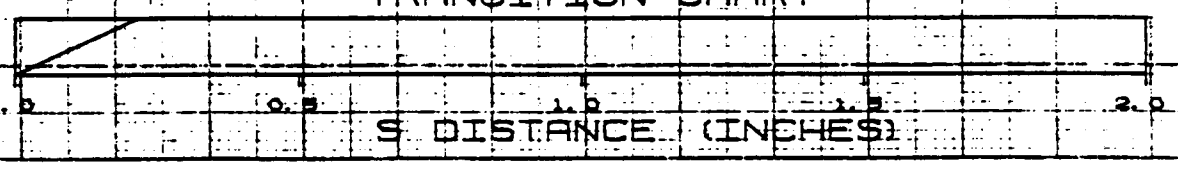
JRFUEL2 U76 RLF= 5.20 RTF= 5.20

4.00% TU

	INLET	EXIT
MACH NO.	0.182	0.403
GAS ANGLES	87.49	29.79

SUCTION SIDE

REF. REYNOLDS NO. 9996457



TRANSITION CHART