FR-20724-3

SSME ALTERNATE TURBOPUMP DEVELOPMENT PROGRAM (HPOTP)

VERIFICATION COMPLETE REPORT SECOND TURBINE VANE AERODYNAMIC DESIGN DVS DR NO. 3.1.2.2.5.1, VM NO. 4.1.2.4 A

JUNE 1989

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Marshall Space Flight Center, Al 35812

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(NASA-CR-183761) SSME ALTERNATE TURBOPUMP DEVELOPMENT PROGRAM (HPOTP). VERIFICATION COMPLETE REPORT: SECOND TURBINE VANE AERODYNAMIC DESIGN DVS DR NO. 3.1.2.2.5.1, VM NO. 4.1.2.4-A (PWA) 35 p

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HPOTP Turbine Aerodynamic Design

The High Pressure Oxidizer Turbopump (HPOTP) 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 3-stage turbine was selected over a 2-stage design for three basic reasons:

1. To retain desired efficiency at the reduced pump speeds.

2. To provide adequate performance margin with unshrouded blades.

3. To ensure adequate margins for adjusting to cycle requirements.

A conventional pressure-compounded, 3-stage design was chosen because of its inherent high efficiency with low aerodynamic risk. This aerodynamic advantage allowed the use of unshrouded blades. Unshrouded blades are desirable because they permit the use of PW1480 single-crystal material, which provides superior thermal fatigue characteristics, but at the present state-of-the-art, cannot be easily cast in the form of shrouded blades in this small size. The turbine aerodynamic design provides relatively high velocity ratios, which are within the range of normal design practice and experience. Avoiding lower velocity ratios eliminates excessive gas turning, and the need for blades with excessively small leading edge radii. Blades with sharp leading edges make the turbine intolerant at incidence angle changes resulting from off-design operation. Under such conditions, severe flow separation is common.

The methodology associated with the design of the HPOTP 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

SPACE SHUTTLE

ENGINE A.T.D. Oxidizer Pump Turbine

AIRFOIL 2nd Vane

ENGINEER Branstrom EXT 2824 DATE

AERODYNAMIC DESIGN POINT 109% Power - Des. Table 0387.8 Dated 4/10/87

F.T.D. LIST:

ELEVATION

AIRFOIL SECTIONS N.A.

AIRFOIL COORDINATES N.A.

DF LIST:

GAGING VS. RADIUS N.A.

FLOW AREA VS. ROTATION N.A.

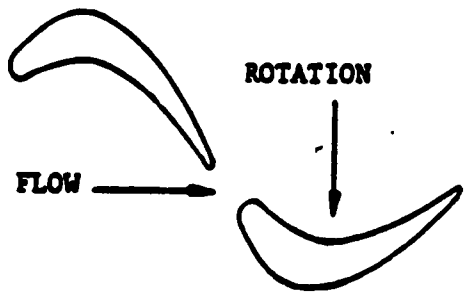
STRESS VS. % SPAN N.A.

PRESSURE DIST. N.A.

BOUNDARY LAYER N.A.

P&WA COUNTER ROTATION

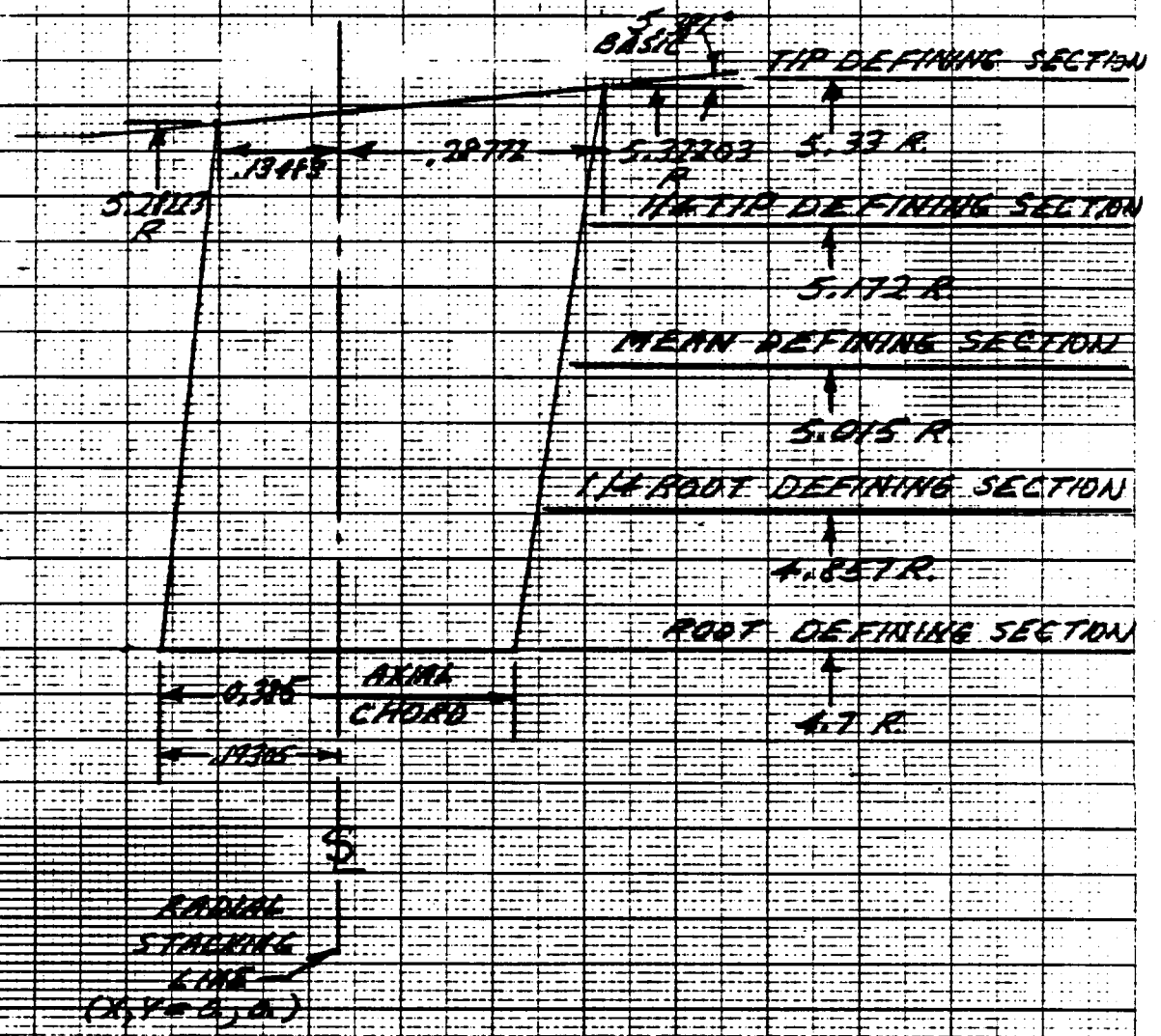
VANE ✓ BLADE



VIEW LOOKING RADIALLY INWARD

2

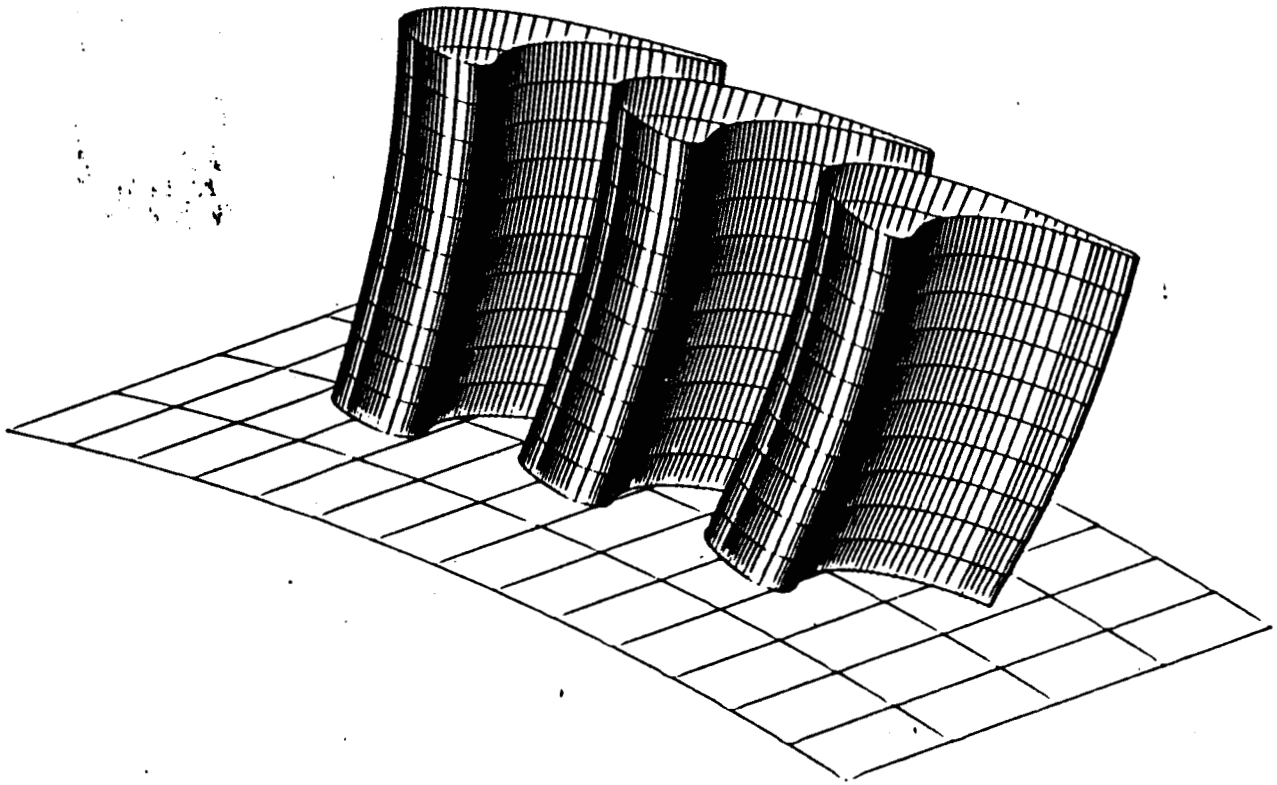
SSME HPOTP SECOND STAGE VANE HOT ELEVATION



NOTES:
1. VANE IS CURVED LINE FAIRED IN P824.
2. NUMBER OF VANES IS 84.
3. ALL DIMENSIONS ARE HOT.
4. MATERIAL IS PWA1480. DENSITY = .311 #/IN.^{3}
5. NET WEIGHT IS 0.0895 #/FOIL.
6. AIRFOIL P824 COORDINATES RESIDE IN RJRP824 LOXHAVE 2.

R. J. R. 11/20/87

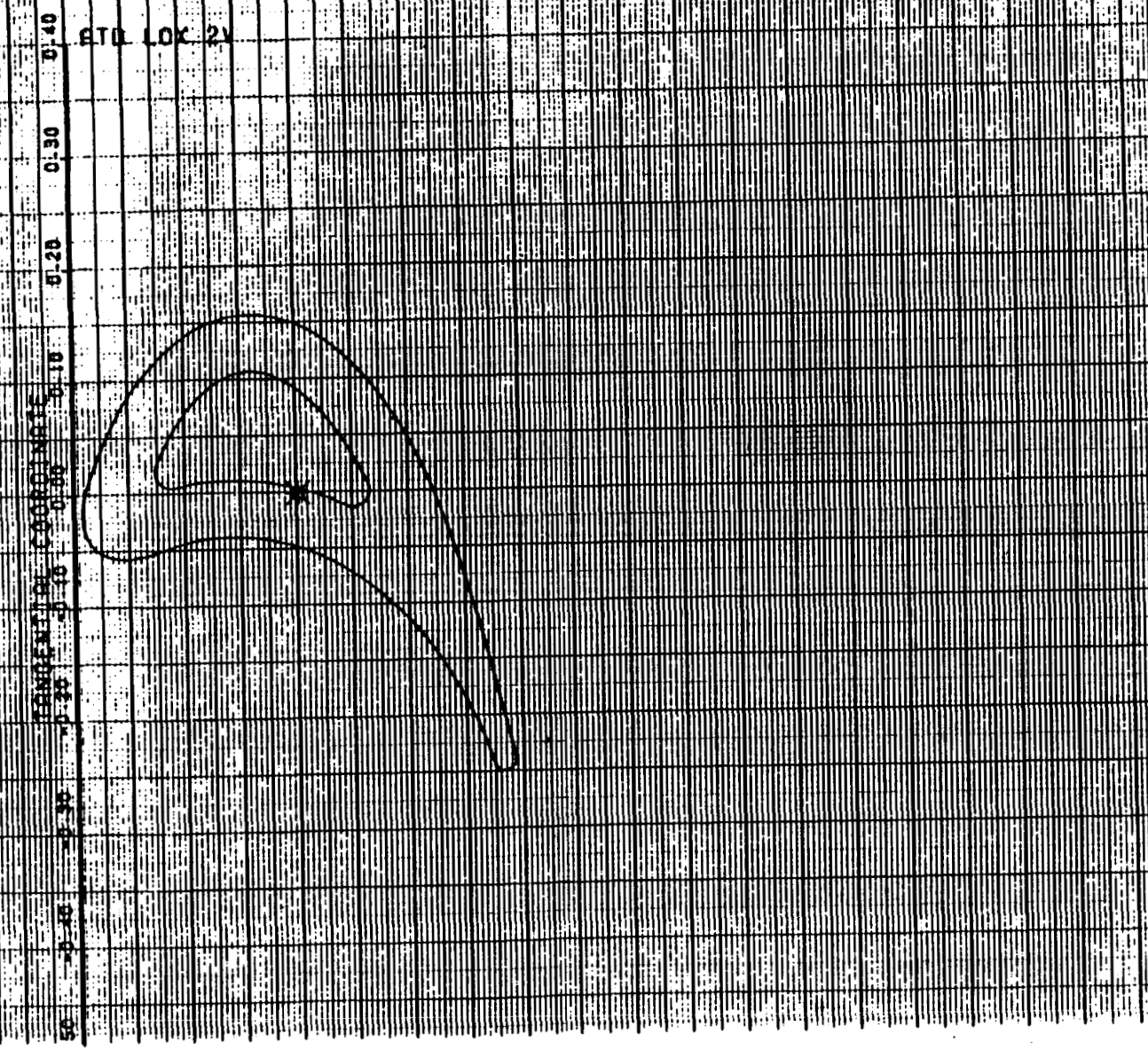
3DPLOT



02/10/8808.50.58

ATC 10X 2V

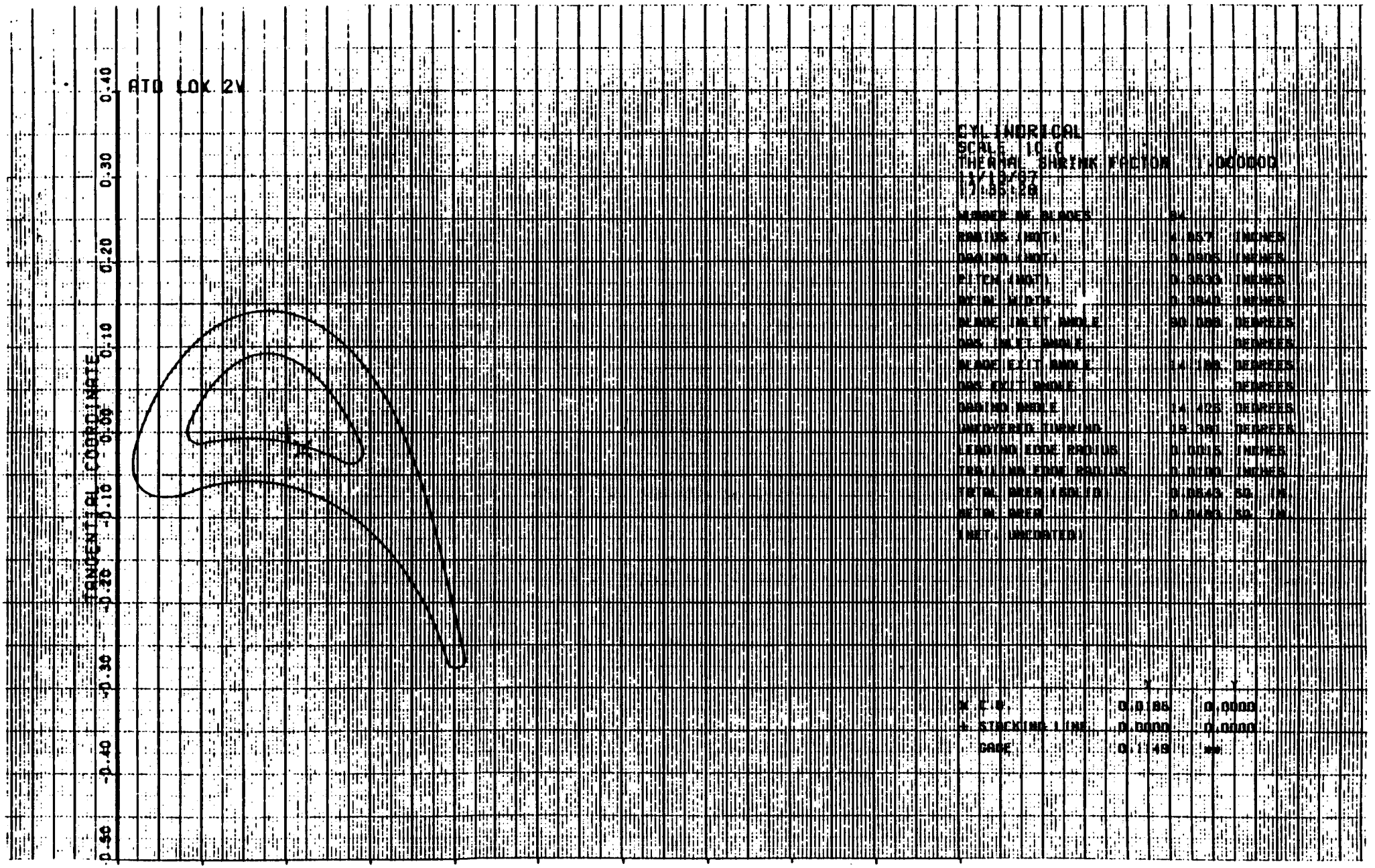
53.26 58.53 19.43



CYLINDRICAL
SCALE 10.0
THERMAL SHRINK FACTOR 1.000000
11/10/87
17:55:28

NUMBER OF BLADES	24	
RADIUS (HOT)	4.700	INCHES
DRAINO (HOT)	0.0043	INCHES
PITCH (HOT)	0.3518	INCHES
BLADE WIDTH	0.1850	INCHES
BLADE INLET ANGLE	90.041	DEGREES
DAS INLET ANGLE		DEGREES
BLADE EXIT ANGLE	18.193	DEGREES
DAS EXIT ANGLE		DEGREES
DRAINO ANGLE	15.553	DEGREES
UNCOVERED TURNING	17.268	DEGREES
LEADING EDGE RADIUS	0.0022	INCHES
TRAILING EDGE RADIUS	0.0107	INCHES
TOTAL AREA (SOLID)	0.0803	SQ. IN.
NET AREA	0.0482	SQ. IN.
(NET UNCOVERED)		

	X	Y
X C.G.	-0.0000	0.0000
X STACKING LINE	0.0000	0.0000
CHORD	0.0924	**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TANGENTIAL COORDINATE
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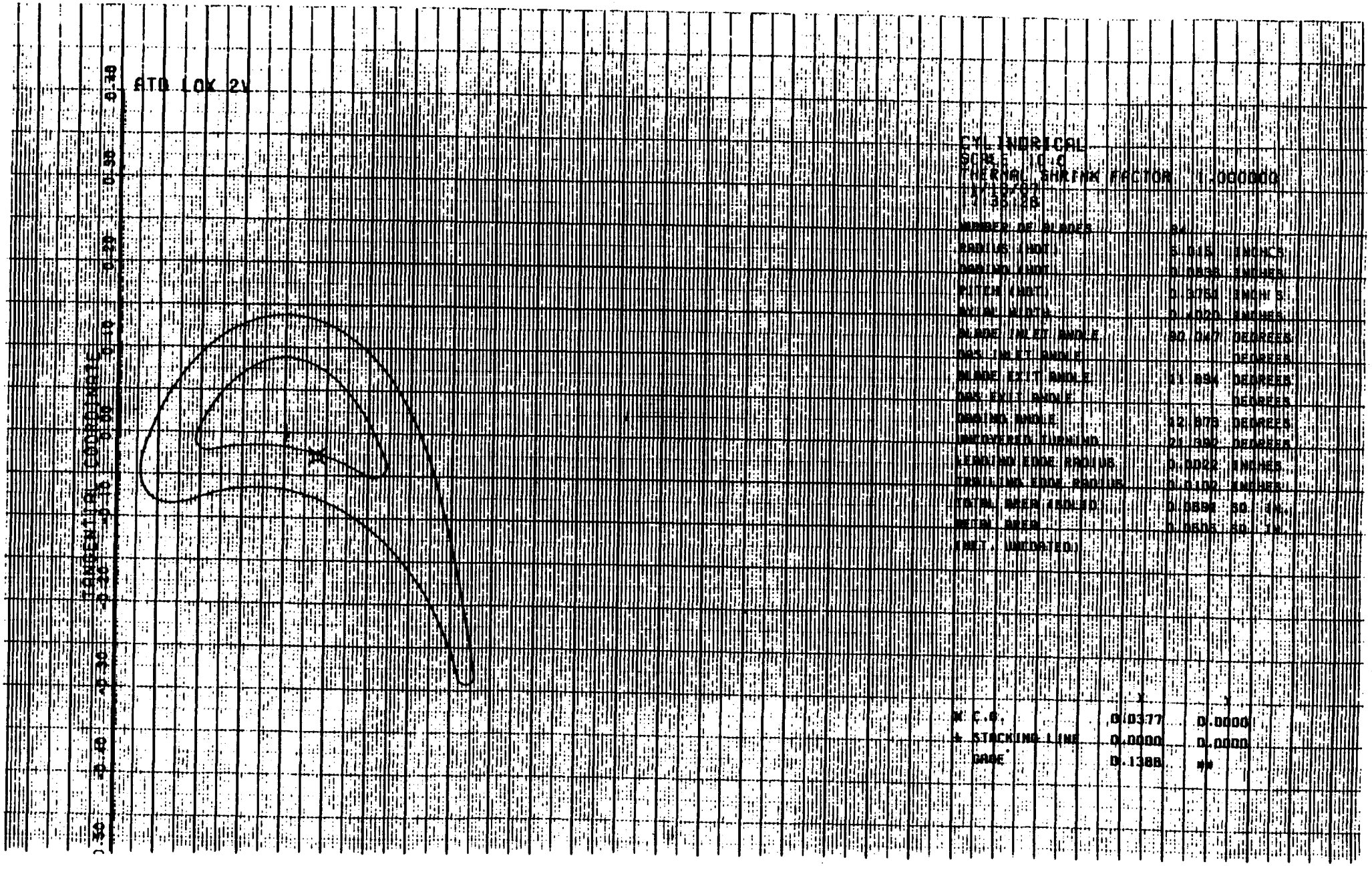
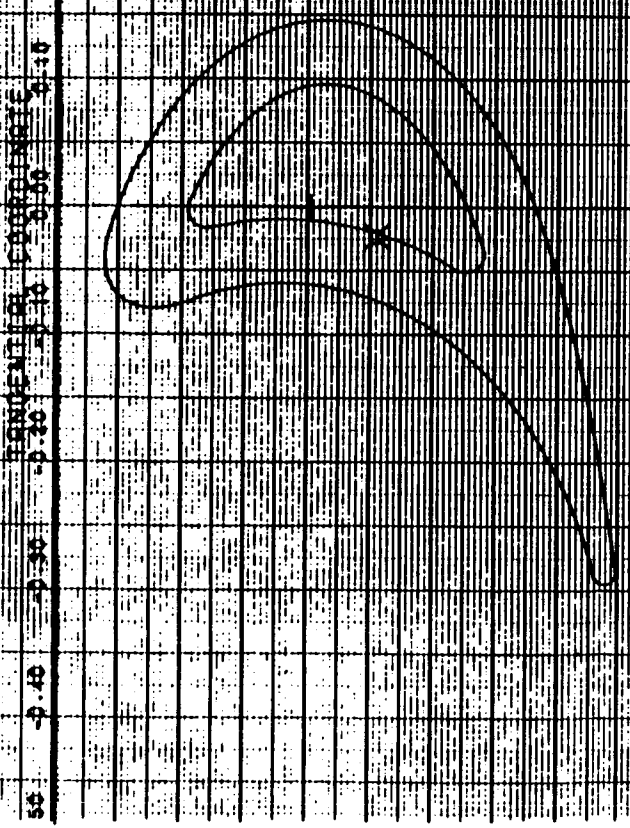
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
CYLINDRICAL
SCALE 10.0
THERMAL SHRINK FACTOR 1.000000
11/19/87
17:35:28
NUMBER OF BLADES 84
RADIUS (HOT) 4.857 INCHES
DAMING (HOT) 0.0905 INCHES
PITCH (HOT) 0.3533 INCHES
AXIAL WIDTH 0.3940 INCHES
BLADE INLET ANGLE 90.000 DEGREES
GAS INLET ANGLE DEGREES
BLADE EXIT ANGLE 14.100 DEGREES
GAS EXIT ANGLE DEGREES
DAMING ANGLE 14.425 DEGREES
UNCOVERED TURNING 19.381 DEGREES
LEADING EDGE RADIUS 0.0015 INCHES
TRAILING EDGE RADIUS 0.0100 INCHES
TOTAL AREA (SOLID) 0.0543 SQ. IN.
METAL AREA 0.0483 SQ. IN.
(NET, UNCOATED)
X Y
X C.G. 0.0185 0.0000
+ STACKING LINE 0.0000 0.0000
GAGE 0.1149 **


ATD LOX 2V
TANGENTIAL COORDINATE
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.50
CYLINDRICAL
SCALE 10.0
THERMAL SHRINK FACTOR 1.000000
NUMBER OF BLADES 84
RADIUS (HOT) 5.015 INCHES
DAMING (HOT) 0.0838 INCHES
PITCH (HOT) 0.3751 INCHES
AXIAL WIDTH 0.4020 INCHES
BLADE INLET ANGLE 90.047 DEGREES
GAS INLET ANGLE DEGREES
BLADE EXIT ANGLE 11.894 DEGREES
GAS EXIT ANGLE DEGREES
DAMING ANGLE 12.878 DEGREES
UNCOVERED TURNING 21.392 DEGREES
LEADING EDGE RADIUS 0.0022 INCHES
TRAILING EDGE RADIUS 0.0102 INCHES
TOTAL AREA (SOLID) 0.0594 SQ. IN.
METAL AREA 0.0505 SQ. IN.
(NET, UNCOATED)
X Y
C.G. 0.0377 0.0000
STACKING LINE 0.0000 0.0000
GAGE 0.1388 **

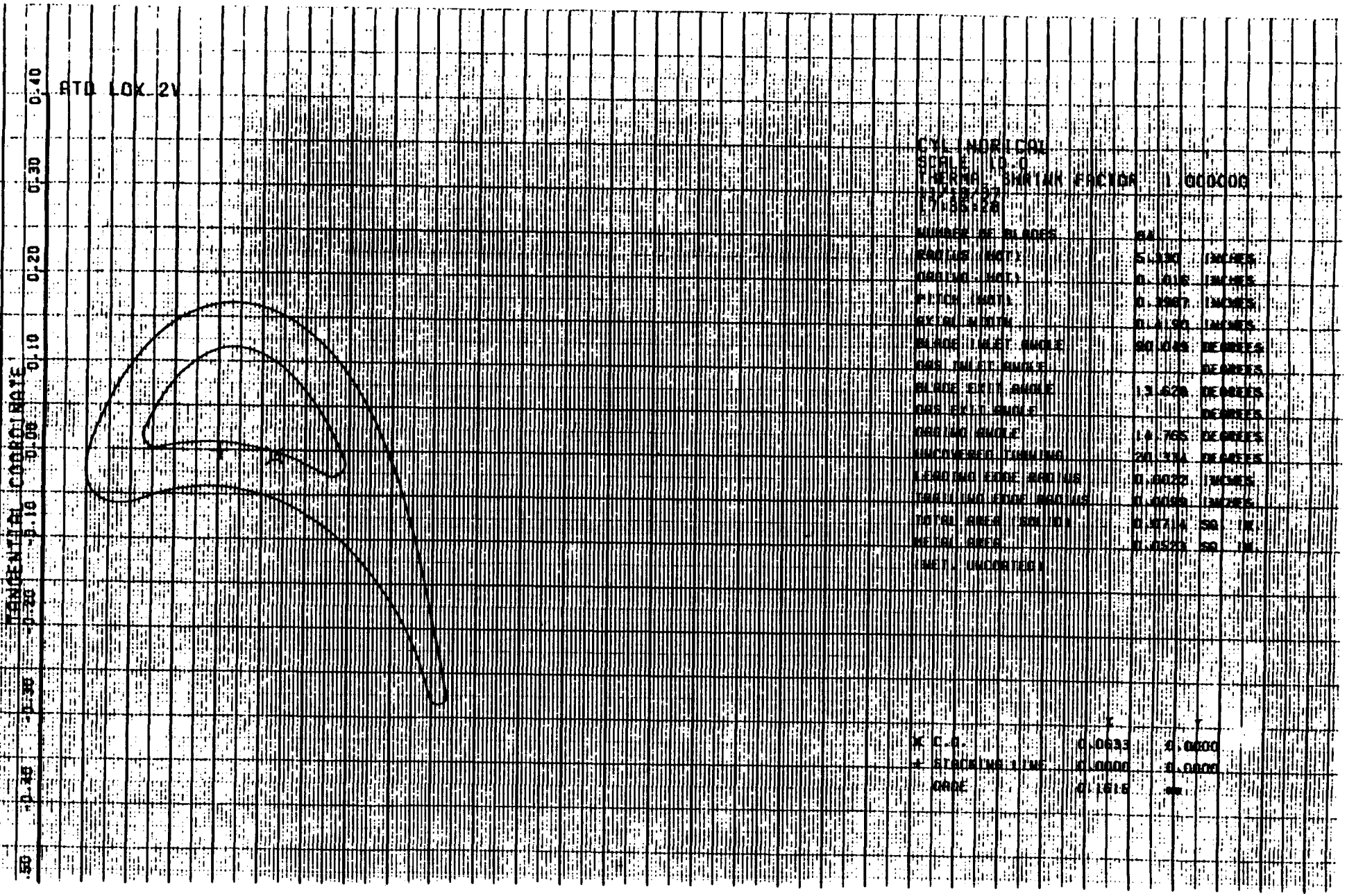
ATD LOX 2V



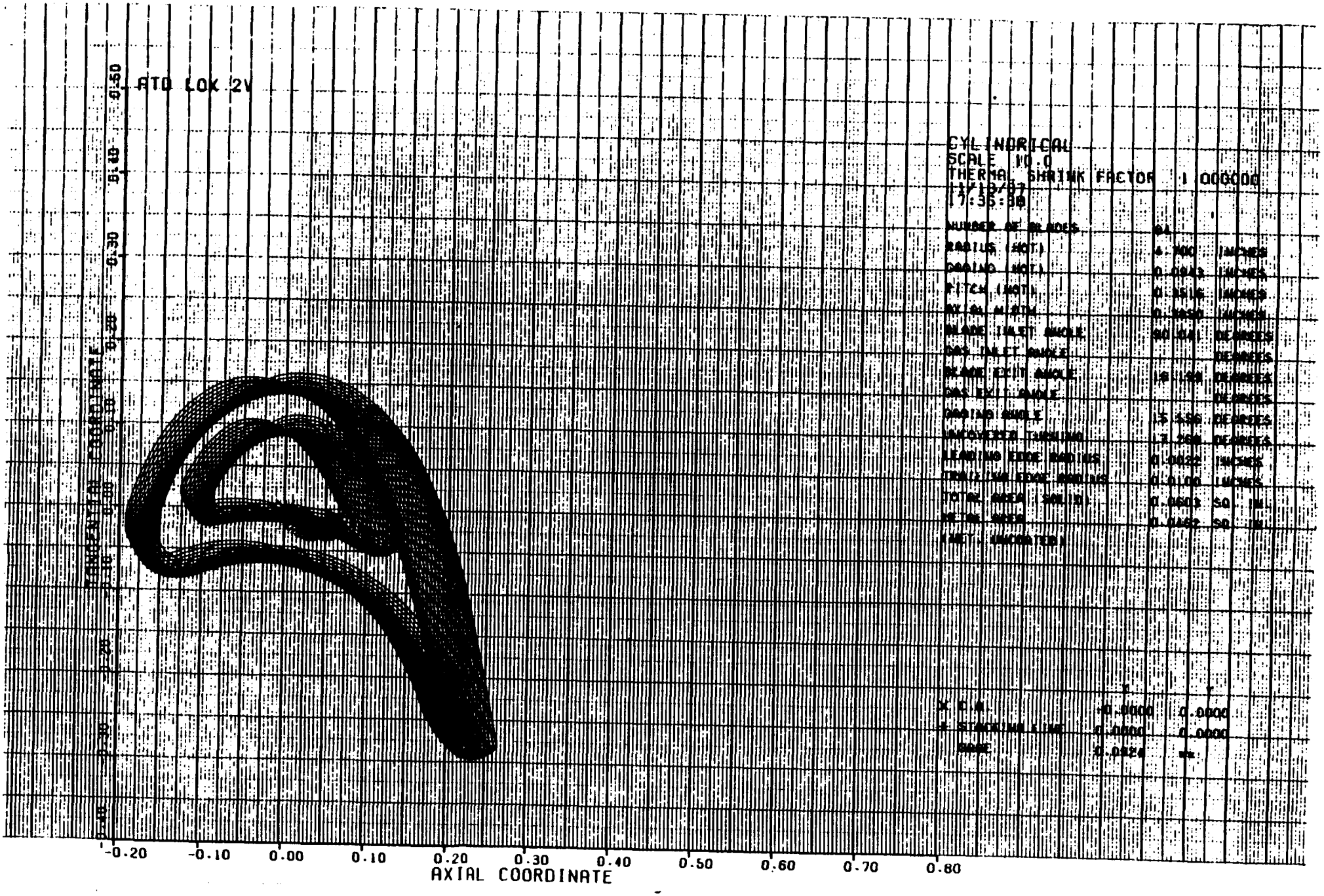
CYLINDRICAL
SCALE 10.0
THERMAL SHRINK FACTOR 1.000000
11/10/87
10:35:28

NUMBER OF BLADES	84	
RADIUS (HOT)	5.172	INCHES
DRAWING (HOT)	0.0881	INCHES
PITCH (HOT)	0.3869	INCHES
AXIAL WIDTH	0.4100	INCHES
BLADE INLET ANGLE	90.058	DEGREES
GAS INLET ANGLE		DEGREES
BLADE EXIT ANGLE	11.953	DEGREES
GAS EXIT ANGLE		DEGREES
DRAWING ANGLE	12.855	DEGREES
UNCOVERED TURNING	21.872	DEGREES
LEADING EDGE RADIUS	0.0020	INCHES
TRAILING EDGE RADIUS	0.0102	INCHES
THRU AREA (SOLID)	0.0717	SQ IN.
METAL AREA	0.0519	SQ IN.
(NET, UNCORRECTED)		

	X	Y
M C.G.	0.0527	0.0000
+ STACKING LINE	0.0000	0.0000
GAGE	0.1547	**



ATD LOX 2V
TANGENTIAL COORDINATE
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-.50
CYLINDRICAL
SCALE 10.0
THERMAL SHRINK FACTOR 1.000000
NUMBER OF BLADES 84
RADIUS (HOT) 5.330 INCHES
RADIUS (HOT) 0.016 INCHES
PITCH (HOT) 0.3987 INCHES
AXIAL WIDTH 0.4190 INCHES
BLADE INLET ANGLE 90.049 DEGREES
GAS INLET ANGLE DEGREES
BLADE EXIT ANGLE 13.628 DEGREES
GAS EXIT ANGLE DEGREES
RADIUS ANGLE 14.765 DEGREES
UNCOVERED TURNING 20.334 DEGREES
LEADING EDGE RADIUS 0.0022 INCHES
TRAILING EDGE RADIUS 0.0099 INCHES
TOTAL AREA (SOLID) 0.0714 SQ. IN.
METAL AREA 0.0523 SQ. IN.
(NET, UNCOATED)
X C.G. 0.0633 0.0000
+ STACKING LINE 0.0000 0.0000
GAGE 0.1616 **


ATD LOX 2V
CYLINDRICAL
SCALE 10.0
THERMAL SHRINK FACTOR 1.000000
11/19/87
17:35:38
NUMBER OF BLADES 84
RADIUS (HOT) 4.700 INCHES
GAGING (HOT) 0.0943 INCHES
PITCH (HOT) 0.3516 INCHES
AXIAL WIDTH 0.3850 INCHES
BLADE INLET ANGLE 90.041 DEGREES
GAS INLET ANGLE DEGREES
BLADE EXIT ANGLE 16.199 DEGREES
GAS EXIT ANGLE DEGREES
GAGING ANGLE 15.556 DEGREES
UNCOVERED TURNING 17.268 DEGREES
LEADING EDGE RADIUS 0.0022 INCHES
TRAILING EDGE RADIUS 0.0100 INCHES
TOTAL AREA (SOLID) 0.0603 SQ. IN.
METAL AREA 0.0462 SQ. IN.
(NET, UNCOATED)
X Y
X C.G. -0.0000 0.0000
STACKING LINE 0.0000 0.0000
GAGE 0.0924 **
TANGENTIAL COORDINATE
0.50
0.40
0.30
0.20
0.10
0.00
-0.10
-0.20
-0.30
-0.40
-0.20
-0.10
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
0.80
AXIAL COORDINATE

EXTERNAL C. .OUR TITLE - ATD LOX 2V
TD 0 TD REV. 0 PART NO. EMD NO. DATE 11/18/87 TIME 12:20:23 CYLINDRICAL
SUBTITLE HOT RADIUS = 4.70000 COLD RADIUS = 0.0 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	-0.19305	-0.01849	-0.01855	-0.19305	-0.01861	-0.01855				
0.010	-0.18920	0.00555		-0.18920	-0.03794					
0.020	-0.18535	0.01704		-0.18535	-0.04426					
0.030	-0.18150	0.02739		-0.18150	-0.04834					
0.040	-0.17765	0.03693		-0.17765	-0.05122					
0.050	-0.17380	0.04576		-0.17380	-0.05330					
0.060	-0.16995	0.05398		-0.16995	-0.05480					
0.070	-0.16610	0.06164		-0.16610	-0.05584		L.E. CIRCLE (X,Y,R)	-0.19080	-0.01855	0.00225
0.080	-0.16225	0.06881		-0.16225	-0.05650		T.E. CIRCLE (X,Y,R)	0.18198	-0.23883	0.00997
0.090	-0.15840	0.07554		-0.15840	-0.05684					
0.100	-0.15455	0.08185		-0.15455	-0.05691		L.E. TOP TANG. PT. (X,Y)	-0.19304	-0.01837	
0.125	-0.14492	0.09606		-0.14492	-0.05606		L.E. BOTTOM TANG. PT. (X,Y)	-0.19304	-0.01872	
0.150	-0.13530	0.10827		-0.13530	-0.05398		T.E. TOP TANG. PT. (X,Y)	0.19167	-0.23649	
0.175	-0.12568	0.11877		-0.12568	-0.05087		T.E. BOTTOM TANG. PT. (X,Y)	0.17253	-0.24205	
0.200	-0.11605	0.12778		-0.11605	-0.04754					
0.225	-0.10643	0.13542		-0.10643	-0.04475		NOSE POINT (X,Y)	-0.18274	-0.04758	
0.250	-0.09680	0.14181		-0.09680	-0.04248		TAIL POINT (X,Y)	0.18476	-0.24841	
0.275	-0.08718	0.14704		-0.08718	-0.04074					
0.300	-0.07755	0.15119		-0.07755	-0.03951		NET CROSS-SECT. AREA (EXCL. COATING)	0.04623		
0.325	-0.06793	0.15429		-0.06793	-0.03878					
0.350	-0.05830	0.15641		-0.05830	-0.03856		GAGING (X,Y,LAMBDA)	0.09245	0.05931	0.09428
0.375	-0.04868	0.15755		-0.04868	-0.03883		GAGING ANGLE (DEG.)	15.556		
0.400	-0.03905	0.15776		-0.03905	-0.03961					
0.425	-0.02943	0.15703		-0.02943	-0.04090		CTR. OF GRAV. (INCL. COATING) (X,Y)	-0.00000	-0.00001	
0.450	-0.01980	0.15539		-0.01980	-0.04270		RAD. REF. PT. (X,Y)	0.0	0.0	
0.475	-0.01018	0.15282		-0.01018	-0.04501		INLET ANGLE (DEG.)	90.042		
0.500	-0.00055	0.14931		-0.00055	-0.04786		INLET WEDGE ANGLE (DEG.)	171.185		
0.525	0.00907	0.14486		0.00907	-0.05125		EXIT ANGLE (DEG.)	16.199		
0.550	0.01870	0.13943		0.01870	-0.05520		EXIT WEDGE ANGLE (DEG.)	5.264		
0.575	0.02832	0.13300		0.02832	-0.05973		UNCOVERED TURNING ANGLE (DEG.)	17.268		
0.600	0.03795	0.12552		0.03795	-0.06487		AXIAL CHORD	0.38500		
0.625	0.04757	0.11692		0.04757	-0.07063		ACTUAL CHORD	0.44522		
0.650	0.05720	0.10714		0.05720	-0.07707		PITCH	0.35156		
0.675	0.06682	0.09606		0.06682	-0.08422		NO. OF FOILS	84		
0.700	0.07645	0.08360		0.07645	-0.09212					
0.725	0.08607	0.06956		0.08607	-0.10085					
0.750	0.09570	0.05374		0.09570	-0.11048					
0.775	0.10532	0.03585		0.10532	-0.12110					
0.800	0.11495	0.01559		0.11495	-0.13286					
0.825	0.12457	-0.00728		0.12457	-0.14590					
0.850	0.13420	-0.03287		0.13420	-0.16041					
0.875	0.14382	-0.06121		0.14382	-0.17673					
0.900	0.15345	-0.09224		0.15345	-0.19533					
0.910	0.15730	-0.10534		0.15730	-0.20353					
0.920	0.16115	-0.11880		0.16115	-0.21228					
0.930	0.16500	-0.13262		0.16500	-0.22169					
0.940	0.16885	-0.14678		0.16885	-0.23174					
0.950	0.17270	-0.16125		0.17270	-0.24254	-0.24250				
0.960	0.17655	-0.17601		0.17655	-0.25476	-0.24720				
0.970	0.18040	-0.19103		0.18040	-0.26910	-0.24868				
0.980	0.18425	-0.20631		0.18425	-0.28569	-0.24854				
0.990	0.18810	-0.22185		0.18810	-0.30453	-0.24670				
1.000	0.19195	-0.23764	-0.23883	0.19195	-0.32563	-0.23883				

NO. 1 CORE CONTOUR TITLE - ATD LOX 2V

TD 0 TD REV. 0 PART NO. EMD NO. DATE 11/18/87 TIME 12:20:23 CYLINDRICAL

SUBTITLE HOT RADIUS = 4.70000 COLD RADIUS = 0.0 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	-0.12847	0.02355	0.02048	-0.12847	0.00096	0.02048				
0.010	-0.12654	0.02804		-0.12654	0.00154	0.01311				
0.020	-0.12461	0.03235		-0.12461	0.00211	0.01042				
0.030	-0.12268	0.03646		-0.12268	0.00265	0.00862				
0.040	-0.12075	0.04038		-0.12075	0.00318	0.00734				
0.050	-0.11882	0.04411		-0.11882	0.00369	0.00643				
0.060	-0.11689	0.04767		-0.11689	0.00419	0.00584				
0.070	-0.11497	0.05105		-0.11497	0.00467	0.00551	L.E. CIRCLE (X,Y,R)	-0.11342	0.02048	0.01505
0.080	-0.11304	0.05427		-0.11304	0.00513	0.00543	T.E. CIRCLE (X,Y,R)	0.04945	0.00223	0.01500
0.090	-0.11111	0.05734		-0.11111	0.00557	0.00561				
0.100	-0.10918	0.06026		-0.10918	0.00600		L.E. TOP TANG. PT. (X,Y)	-0.12724	0.02645	
0.125	-0.10435	0.06702		-0.10435	0.00700		L.E. BOTTOM TANG. PT. (X,Y)	-0.11015	0.00579	
0.150	-0.09953	0.07311		-0.09953	0.00790		T.E. TOP TANG. PT. (X,Y)	0.06294	0.00878	
0.175	-0.09471	0.07869		-0.09471	0.00869		T.E. BOTTOM TANG. PT. (X,Y)	0.04317	-0.01139	
0.200	-0.08989	0.08379		-0.08989	0.00938					
0.225	-0.08506	0.08841		-0.08506	0.00997		NOSE POINT (X,Y)	-0.12502	0.01089	
0.250	-0.08024	0.09253		-0.08024	0.01046		TAIL POINT (X,Y)	0.06016	-0.00827	
0.275	-0.07542	0.09614		-0.07542	0.01085					
0.300	-0.07059	0.09924		-0.07059	0.01115					
0.325	-0.06577	0.10186		-0.06577	0.01134					
0.350	-0.06095	0.10400		-0.06095	0.01143					
0.375	-0.05613	0.10567		-0.05613	0.01143					
0.400	-0.05130	0.10686		-0.05130	0.01133					
0.425	-0.04648	0.10757		-0.04648	0.01112					
0.450	-0.04166	0.10779		-0.04166	0.01082					
0.475	-0.03683	0.10755		-0.03683	0.01042					
0.500	-0.03201	0.10685		-0.03201	0.00991					
0.525	-0.02719	0.10572		-0.02719	0.00931					
0.550	-0.02236	0.10416		-0.02236	0.00860					
0.575	-0.01754	0.10219		-0.01754	0.00780					
0.600	-0.01272	0.09983		-0.01272	0.00689					
0.625	-0.00790	0.09709		-0.00790	0.00588					
0.650	-0.00307	0.09396		-0.00307	0.00477					
0.675	0.00175	0.09045		0.00175	0.00355					
0.700	0.00657	0.08657		0.00657	0.00223					
0.725	0.01140	0.08231		0.01140	0.00080					
0.750	0.01622	0.07765		0.01622	-0.00074					
0.775	0.02104	0.07259		0.02104	-0.00239					
0.800	0.02587	0.06712		0.02587	-0.00415					
0.825	0.03069	0.06122		0.03069	-0.00602					
0.850	0.03551	0.05487		0.03551	-0.00800					
0.875	0.04033	0.04805		0.04033	-0.01010					
0.900	0.04516	0.04076		0.04516	-0.01232	-0.01214				
0.910	0.04709	0.03769		0.04709	-0.01324	-0.01258				
0.920	0.04902	0.03453		0.04902	-0.01418	-0.01276				
0.930	0.05095	0.03127		0.05095	-0.01514	-0.01270				
0.940	0.05287	0.02792		0.05287	-0.01612	-0.01237				
0.950	0.05480	0.02447		0.05480	-0.01712	-0.01178				
0.960	0.05673	0.02093		0.05673	-0.01814	-0.01088				
0.970	0.05866	0.01728		0.05866	-0.01918	-0.00961				
0.980	0.06059	0.01352		0.06059	-0.02024	-0.00781				
0.990	0.06252	0.00964		0.06252	-0.02132	-0.00513				
1.000	0.06445	0.00565	0.00223	0.06445	-0.02243	0.00223				

EXTERNAL C...TOUR TITLE - ATD LOX 2V

TD 0 TD REV. 0 PART NO. EMD NO. DATE 11/18/87 TIME 12:20:23 CYLINDRICAL

SUBTITLE HOT RADIUS = 4.85700 COLD RADIUS = 0.0 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	-0.18296	-0.03690	-0.03696	-0.18296	-0.03698	-0.03696				
0.010	-0.17902	-0.01254		-0.17902	-0.05652					
0.020	-0.17508	-0.00086		-0.17508	-0.06288					
0.030	-0.17114	0.00963		-0.17114	-0.06696					
0.040	-0.16720	0.01925		-0.16720	-0.06983					
0.050	-0.16326	0.02813		-0.16326	-0.07189					
0.060	-0.15932	0.03638		-0.15932	-0.07336					
0.070	-0.15538	0.04406		-0.15538	-0.07436		L.E. CIRCLE (X,Y,R)	-0.18147	-0.03694	0.00149
0.080	-0.15144	0.05125		-0.15144	-0.07498		T.E. CIRCLE (X,Y,R)	0.20102	-0.26610	0.01002
0.090	-0.14750	0.05798		-0.14750	-0.07527					
0.100	-0.14356	0.06430		-0.14356	-0.07528		L.E. TOP TANG. PT. (X,Y)	-0.18295	-0.03678	
0.125	-0.13371	0.07854		-0.13371	-0.07426		L.E. BOTTOM TANG. PT. (X,Y)	-0.18295	-0.03709	
0.150	-0.12386	0.09080		-0.12386	-0.07199		T.E. TOP TANG. PT. (X,Y)	0.21083	-0.26407	
0.175	-0.11401	0.10138		-0.11401	-0.06868		T.E. BOTTOM TANG. PT. (X,Y)	0.19142	-0.26898	
0.200	-0.10416	0.11051		-0.10416	-0.06535					
0.225	-0.09431	0.11831		-0.09431	-0.06257		NOSE POINT (X,Y)	-0.17273	-0.06583	
0.250	-0.08446	0.12490		-0.08446	-0.06032		TAIL POINT (X,Y)	0.20348	-0.27581	
0.275	-0.07461	0.13038		-0.07461	-0.05858					
0.300	-0.06476	0.13481		-0.06476	-0.05736		NET CROSS-SECT. AREA (EXCL. COATING)	0.04833		
0.325	-0.05491	0.13824		-0.05491	-0.05664					
0.350	-0.04506	0.14072		-0.04506	-0.05642		GAGING (X,Y,LAMBDA)	0.11492	0.04532	0.09051
0.375	-0.03521	0.14228		-0.03521	-0.05671		GAGING ANGLE (DEG.)	14.426		
0.400	-0.02536	0.14293		-0.02536	-0.05750					
0.425	-0.01551	0.14269		-0.01551	-0.05879		CTR. OF GRAV. (INCL. COATING) (X,Y)	0.01854	-0.01861	
0.450	-0.00566	0.14156		-0.00566	-0.06060		RAD. REF. PT. (X,Y)	0.0	0.0	
0.475	0.00419	0.13956		0.00419	-0.06292		INLET ANGLE (DEG.)	90.088		
0.500	0.01404	0.13666		0.01404	-0.06578		INLET WEDGE ANGLE (DEG.)	168.031		
0.525	0.02389	0.13284		0.02389	-0.06919		EXIT ANGLE (DEG.)	14.188		
0.550	0.03374	0.12810		0.03374	-0.07315		EXIT WEDGE ANGLE (DEG.)	4.996		
0.575	0.04359	0.12239		0.04359	-0.07770		UNCOVERED TURNING ANGLE (DEG.)	19.381		
0.600	0.05344	0.11566		0.05344	-0.08286		AXIAL CHORD	0.39400		
0.625	0.06329	0.10786		0.06329	-0.08867		ACTUAL CHORD	0.45740		
0.650	0.07314	0.09891		0.07314	-0.09515		PITCH	0.36330		
0.675	0.08299	0.08871		0.08299	-0.10235		NO. OF FOILS	84		
0.700	0.09284	0.07716		0.09284	-0.11034					
0.725	0.10269	0.06406		0.10269	-0.11917					
0.750	0.11254	0.04920		0.11254	-0.12894					
0.775	0.12239	0.03226		0.12239	-0.13974					
0.800	0.13224	0.01282		0.13224	-0.15174					
0.825	0.14209	-0.00954		0.14209	-0.16512					
0.850	0.15194	-0.03520		0.15194	-0.18010					
0.875	0.16179	-0.06450		0.16179	-0.19708					
0.900	0.17164	-0.09763		0.17164	-0.21667					
0.910	0.17558	-0.11194		0.17558	-0.22543					
0.920	0.17952	-0.12685		0.17952	-0.23484					
0.930	0.18346	-0.14233		0.18346	-0.24500					
0.940	0.18740	-0.15838		0.18740	-0.25620					
0.950	0.19134	-0.17497		0.19134	-0.26869					
0.960	0.19528	-0.19207		0.19528	-0.28257	-0.27431				
0.970	0.19922	-0.20963		0.19922	-0.29787	-0.27595				
0.980	0.20316	-0.22766		0.20316	-0.31459	-0.27589				
0.990	0.20710	-0.24614		0.20710	-0.33274	-0.27406				
1.000	0.21104	-0.26508	-0.26610	0.21104	-0.35232	-0.26610				

NO. 1 CORE .JNTOUR TITLE - ATD LOX 2V

TD 0 TD REV. 0 PART NO. EMD NO. DATE 11/18/87 TIME 12:20:23 CYLINDRICAL

SUBTITLE HOT RADIUS = 4.85700 COLD RADIUS = 0.0 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	-0.11836	0.00558	0.00224	-0.11836	-0.01741	0.00224				
0.010	-0.11626	0.01006		-0.11626	-0.01677	-0.00544				
0.020	-0.11417	0.01438		-0.11417	-0.01616	-0.00821				
0.030	-0.11207	0.01855		-0.11207	-0.01557	-0.01003				
0.040	-0.10997	0.02256		-0.10997	-0.01499	-0.01129				
0.050	-0.10787	0.02642		-0.10787	-0.01444	-0.01214				
0.060	-0.10578	0.03014		-0.10578	-0.01390	-0.01266				
0.070	-0.10368	0.03371		-0.10368	-0.01338	-0.01286	L.E. CIRCLE (X,Y,R)	-0.10325	0.00224	0.01511
0.080	-0.10158	0.03713		-0.10158	-0.01288	-0.01278	T.E. CIRCLE (X,Y,R)	0.07621	-0.02120	0.01513
0.090	-0.09949	0.04039		-0.09949	-0.01240					
0.100	-0.09739	0.04351		-0.09739	-0.01194		L.E. TOP TANG. PT. (X,Y)	-0.11692	0.00868	
0.125	-0.09215	0.05073		-0.09215	-0.01087		L.E. BOTTOM TANG. PT. (X,Y)	-0.09991	-0.01250	
0.150	-0.08690	0.05716		-0.08690	-0.00992		T.E. TOP TANG. PT. (X,Y)	0.09003	-0.01504	
0.175	-0.08166	0.06295		-0.08166	-0.00908		T.E. BOTTOM TANG. PT. (X,Y)	0.06934	-0.03468	
0.200	-0.07642	0.06818		-0.07642	-0.00836					
0.225	-0.07118	0.07289		-0.07118	-0.00775		NOSE POINT (X,Y)	-0.11503	-0.00722	
0.250	-0.06593	0.07709		-0.06593	-0.00726		TAIL POINT (X,Y)	0.08663	-0.03217	
0.275	-0.06069	0.08078		-0.06069	-0.00688					
0.300	-0.05545	0.08396		-0.05545	-0.00662					
0.325	-0.05021	0.08665		-0.05021	-0.00646					
0.350	-0.04496	0.08886		-0.04496	-0.00642					
0.375	-0.03972	0.09059		-0.03972	-0.00650					
0.400	-0.03448	0.09185		-0.03448	-0.00668					
0.425	-0.02924	0.09263		-0.02924	-0.00698					
0.450	-0.02400	0.09295		-0.02400	-0.00739					
0.475	-0.01875	0.09279		-0.01875	-0.00792					
0.500	-0.01351	0.09218		-0.01351	-0.00856					
0.525	-0.00827	0.09113		-0.00827	-0.00932					
0.550	-0.00302	0.08963		-0.00302	-0.01019					
0.575	0.00222	0.08772		0.00222	-0.01117					
0.600	0.00746	0.08538		0.00746	-0.01228					
0.625	0.01270	0.08262		0.01270	-0.01350					
0.650	0.01794	0.07944		0.01794	-0.01484					
0.675	0.02319	0.07584		0.02319	-0.01631					
0.700	0.02843	0.07182		0.02843	-0.01789					
0.725	0.03367	0.06735		0.03367	-0.01960					
0.750	0.03891	0.06244		0.03891	-0.02144					
0.775	0.04416	0.05707		0.04416	-0.02340					
0.800	0.04940	0.05123		0.04940	-0.02549					
0.825	0.05464	0.04486		0.05464	-0.02772					
0.850	0.05988	0.03795		0.05988	-0.03007					
0.875	0.06513	0.03045		0.06513	-0.03257					
0.900	0.07037	0.02235		0.07037	-0.03521	-0.03516				
0.910	0.07247	0.01892		0.07247	-0.03630	-0.03586				
0.920	0.07456	0.01536		0.07456	-0.03742	-0.03624				
0.930	0.07666	0.01168		0.07666	-0.03856	-0.03632				
0.940	0.07876	0.00787		0.07876	-0.03973	-0.03612				
0.950	0.08085	0.00392		0.08085	-0.04092	-0.03560				
0.960	0.08295	-0.00015		0.08295	-0.04214	-0.03475				
0.970	0.08505	-0.00437		0.08505	-0.04338	-0.03348				
0.980	0.08715	-0.00875		0.08715	-0.04464	-0.03166				
0.990	0.08924	-0.01330		0.08924	-0.04593	-0.02889				
1.000	0.09134	-0.01801	-0.02120	0.09134	-0.04724	-0.02120				

EXTERNAL C...OUR TITLE - ØTD LOX 2V

TD 0 TD REV. 0 PART NO. EMD NO. DATE 11/18/87 TIME 12:20:23 CYLINDRICAL

SUBTITLE HOT RADIUS = 5.01500 COLD RADIUS = 0.0 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	-0.17280	-0.04506	-0.04512	-0.17280	-0.04518	-0.04512				
0.010	-0.16878	-0.02045		-0.16878	-0.06486					
0.020	-0.16476	-0.00862		-0.16476	-0.07125					
0.030	-0.16074	0.00195		-0.16074	-0.07534					
0.040	-0.15672	0.01159		-0.15672	-0.07820					
0.050	-0.15270	0.02045		-0.15270	-0.08024					
0.060	-0.14868	0.02866		-0.14868	-0.08168					
0.070	-0.14466	0.03630		-0.14466	-0.08264		L.E. CIRCLE (X,Y,R)	-0.17060	-0.04512	0.00220
0.080	-0.14064	0.04343		-0.14064	-0.08322		T.E. CIRCLE (X,Y,R)	0.21899	-0.28220	0.01020
0.090	-0.13662	0.05012		-0.13662	-0.08347					
0.100	-0.13260	0.05640		-0.13260	-0.08343		L.E. TOP TANG. PT. (X,Y)	-0.17279	-0.04494	
0.125	-0.12255	0.07056		-0.12255	-0.08226		L.E. BOTTOM TANG. PT. (X,Y)	-0.17279	-0.04529	
0.150	-0.11250	0.08281		-0.11250	-0.07982		T.E. TOP TANG. PT. (X,Y)	0.22905	-0.28046	
0.175	-0.10245	0.09345		-0.10245	-0.07635		T.E. BOTTOM TANG. PT. (X,Y)	0.20909	-0.28466	
0.200	-0.09240	0.10270		-0.09240	-0.07302					
0.225	-0.08235	0.11069		-0.08235	-0.07024		NOSE POINT (X,Y)	-0.16221	-0.07439	
0.250	-0.07230	0.11754		-0.07230	-0.06799		TAIL POINT (X,Y)	0.22110	-0.29218	
0.275	-0.06225	0.12333		-0.06225	-0.06626					
0.300	-0.05220	0.12814		-0.05220	-0.06503		NET CROSS-SECT. AREA (EXCL. COATING)	0.05053		
0.325	-0.04215	0.13202		-0.04215	-0.06431					
0.350	-0.03210	0.13500		-0.03210	-0.06409		GAGING (X,Y,LAMBDA)	0.13878	0.04434	0.08358
0.375	-0.02205	0.13712		-0.02205	-0.06437		GAGING ANGLE (DEG.)	12.873		
0.400	-0.01200	0.13840		-0.01200	-0.06515					
0.425	-0.00195	0.13885		-0.00195	-0.06643		CTR. OF GRAV. (INCL. COATING) (X,Y)	0.03767	-0.02650	
0.450	0.00810	0.13847		0.00810	-0.06822		RAD. REF. PT. (X,Y)	0.0	0.0	
0.475	0.01815	0.13726		0.01815	-0.07053		INLET ANGLE (DEG.)	90.047		
0.500	0.02820	0.13523		0.02820	-0.07337		INLET WEDGE ANGLE (DEG.)	170.834		
0.525	0.03825	0.13234		0.03825	-0.07676		EXIT ANGLE (DEG.)	11.894		
0.550	0.04830	0.12857		0.04830	-0.08071		EXIT WEDGE ANGLE (DEG.)	4.163		
0.575	0.05835	0.12390		0.05835	-0.08525		UNCOVERED TURNING ANGLE (DEG.)	21.392		
0.600	0.06840	0.11828		0.06840	-0.09039		AXIAL CHORD	0.40200		
0.625	0.07845	0.11165		0.07845	-0.09619		ACTUAL CHORD	0.46847		
0.650	0.08850	0.10394		0.08850	-0.10266		PITCH	0.37512		
0.675	0.09855	0.09503		0.09855	-0.10988		NO. OF FOILS	84		
0.700	0.10860	0.08485		0.10860	-0.11788					
0.725	0.11865	0.07317		0.11865	-0.12675					
0.750	0.12870	0.05980		0.12870	-0.13658					
0.775	0.13875	0.04439		0.13875	-0.14747					
0.800	0.14880	0.02644		0.14880	-0.15962					
0.825	0.15885	0.00532		0.15885	-0.17322					
0.850	0.16890	-0.01971		0.16890	-0.18854					
0.875	0.17895	-0.04944		0.17895	-0.20604					
0.900	0.18900	-0.08460		0.18900	-0.22649					
0.910	0.19302	-0.10027		0.19302	-0.23586					
0.920	0.19704	-0.11688		0.19704	-0.24579					
0.930	0.20106	-0.13443		0.20106	-0.25638					
0.940	0.20508	-0.15290		0.20508	-0.26910					
0.950	0.20910	-0.17228		0.20910	-0.28469	-0.28469				
0.960	0.21312	-0.19252		0.21312	-0.29965	-0.29054				
0.970	0.21714	-0.21355		0.21714	-0.31016	-0.29223				
0.980	0.22116	-0.23536		0.22116	-0.31546	-0.29217				
0.990	0.22518	-0.25796		0.22518	-0.31556	-0.29031				
1.000	0.22920	-0.28134	-0.28220	0.22920	-0.31044	-0.28220				

NO. 1 CORE CONTOUR TITLE - ATD LOX 2V

TD 0 TD REV. 0 PART NO. EMD NO. DATE 11/18/87 TIME 12:20:23 CYLINDRICAL

SUBTITLE HOT RADIUS = 5.01500 COLD RADIUS = 0.0 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	-0.10800	-0.00260	-0.00599	-0.10800	-0.02551	-0.00599				
0.010	-0.10571	0.00216		-0.10571	-0.02482	-0.01394				
0.020	-0.10342	0.00674		-0.10342	-0.02415	-0.01676				
0.030	-0.10114	0.01115		-0.10114	-0.02350	-0.01857				
0.040	-0.09885	0.01538		-0.09885	-0.02287	-0.01978				
0.050	-0.09656	0.01944		-0.09656	-0.02226	-0.02054				
0.060	-0.09427	0.02334		-0.09427	-0.02168	-0.02091				
0.070	-0.09198	0.02708		-0.09198	-0.02112	-0.02092	L.E. CIRCLE (X,Y,R)	-0.09303	-0.00599	0.01497
0.080	-0.08970	0.03064		-0.08970	-0.02059	-0.02059	T.E. CIRCLE (X,Y,R)	0.10580	-0.03683	0.01500
0.090	-0.08741	0.03403		-0.08741	-0.02007					
0.100	-0.08512	0.03726		-0.08512	-0.01958		L.E. TOP TANG. PT. (X,Y)	-0.10650	0.00054	
0.125	-0.07940	0.04470		-0.07940	-0.01844		L.E. BOTTOM TANG. PT. (X,Y)	-0.08968	-0.02058	
0.150	-0.07368	0.05130		-0.07368	-0.01744		T.E. TOP TANG. PT. (X,Y)	0.11984	-0.03155	
0.175	-0.06796	0.05724		-0.06796	-0.01657		T.E. BOTTOM TANG. PT. (X,Y)	0.09832	-0.04984	
0.200	-0.06224	0.06262		-0.06224	-0.01583					
0.225	-0.05652	0.06746		-0.05652	-0.01522		NOSE POINT (X,Y)	-0.10474	-0.01532	
0.250	-0.05080	0.07179		-0.05080	-0.01474		TAIL POINT (X,Y)	0.11551	-0.04826	
0.275	-0.04508	0.07559		-0.04508	-0.01439					
0.300	-0.03936	0.07889		-0.03936	-0.01418					
0.325	-0.03364	0.08169		-0.03364	-0.01409					
0.350	-0.02792	0.08402		-0.02792	-0.01413					
0.375	-0.02220	0.08589		-0.02220	-0.01431					
0.400	-0.01648	0.08730		-0.01648	-0.01461					
0.425	-0.01076	0.08826		-0.01076	-0.01504					
0.450	-0.00504	0.08876		-0.00504	-0.01561					
0.475	0.00068	0.08881		0.00068	-0.01630					
0.500	0.00640	0.08841		0.00640	-0.01713					
0.525	0.01212	0.08756		0.01212	-0.01809					
0.550	0.01784	0.08627		0.01784	-0.01918					
0.575	0.02356	0.08452		0.02356	-0.02041					
0.600	0.02928	0.08233		0.02928	-0.02177					
0.625	0.03500	0.07968		0.03500	-0.02327					
0.650	0.04072	0.07657		0.04072	-0.02492					
0.675	0.04644	0.07299		0.04644	-0.02670					
0.700	0.05216	0.06893		0.05216	-0.02863					
0.725	0.05788	0.06437		0.05788	-0.03071					
0.750	0.06360	0.05927		0.06360	-0.03294					
0.775	0.06932	0.05362		0.06932	-0.03532					
0.800	0.07504	0.04738		0.07504	-0.03785					
0.825	0.08076	0.04048		0.08076	-0.04054					
0.850	0.08648	0.03289		0.08648	-0.04340					
0.875	0.09220	0.02454		0.09220	-0.04642					
0.900	0.09792	0.01533		0.09792	-0.04961					
0.910	0.10021	0.01136		0.10021	-0.05093	-0.05075				
0.920	0.10250	0.00720		0.10250	-0.05229	-0.05147				
0.930	0.10478	0.00284		0.10478	-0.05368	-0.05180				
0.940	0.10707	-0.00172		0.10707	-0.05510	-0.05178				
0.950	0.10936	-0.00651		0.10936	-0.05654	-0.05140				
0.960	0.11165	-0.01152		0.11165	-0.05802	-0.05065				
0.970	0.11394	-0.01678		0.11394	-0.05952	-0.04943				
0.980	0.11622	-0.02229		0.11622	-0.06105	-0.04762				
0.990	0.11851	-0.02807		0.11851	-0.06261	-0.04479				
1.000	0.12080	-0.03412	-0.03683	0.12080	-0.06421	-0.03683				

EXTERNAL L...TOUR TITLE - ATD LOX 2V

TD 0 TD REV. 0 PART NO. EMD NO. DATE 11/18/87 TIME 12:20:23 CYLINDRICAL

SUBTITLE HOT RADIUS = 5.17200 COLD RADIUS = 0.0 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	-0.16271	-0.04019	-0.04024	-0.16271	-0.04030	-0.04024				
0.010	-0.15861	-0.01531		-0.15861	-0.06016					
0.020	-0.15451	-0.00330		-0.15451	-0.06657					
0.030	-0.15041	0.00744		-0.15041	-0.07067					
0.040	-0.14631	0.01723		-0.14631	-0.07351					
0.050	-0.14221	0.02623		-0.14221	-0.07553					
0.060	-0.13811	0.03456		-0.13811	-0.07694					
0.070	-0.13401	0.04232		-0.13401	-0.07787		L.E. CIRCLE (X,Y,R)	-0.16071	-0.04024	0.00200
0.080	-0.12991	0.04956		-0.12991	-0.07841		T.E. CIRCLE (X,Y,R)	0.23710	-0.28523	0.01019
0.090	-0.12581	0.05635		-0.12581	-0.07861					
0.100	-0.12171	0.06273		-0.12171	-0.07851		L.E. TOP TANG. PT. (X,Y)	-0.16270	-0.04007	
0.125	-0.11146	0.07711		-0.11146	-0.07720		L.E. BOTTOM TANG. PT. (X,Y)	-0.16270	-0.04041	
0.150	-0.10121	0.08955		-0.10121	-0.07458		T.E. TOP TANG. PT. (X,Y)	0.24715	-0.28356	
0.175	-0.09096	0.10036		-0.09096	-0.07098		T.E. BOTTOM TANG. PT. (X,Y)	0.22724	-0.28778	
0.200	-0.08071	0.10977		-0.08071	-0.06766					
0.225	-0.07046	0.11790		-0.07046	-0.06490		NOSE POINT (X,Y)	-0.15208	-0.06949	
0.250	-0.06021	0.12488		-0.06021	-0.06267		TAIL POINT (X,Y)	0.23921	-0.29519	
0.275	-0.04996	0.13080		-0.04996	-0.06098					
0.300	-0.03971	0.13572		-0.03971	-0.05980		NET CROSS-SECT. AREA (EXCL. COATING)	0.05187		
0.325	-0.02946	0.13969		-0.02946	-0.05914					
0.350	-0.01921	0.14276		-0.01921	-0.05899		GAGING (X,Y,LAMBDA)	0.15475	0.05166	0.08614
0.375	-0.00896	0.14495		-0.00896	-0.05935		GAGING ANGLE (DEG.)	12.866		
0.400	0.00129	0.14629		0.00129	-0.06023					
0.425	0.01154	0.14679		0.01154	-0.06162		CTR. OF GRAV. (INCL. COATING) (X,Y)	0.05267	-0.02225	
0.450	0.02179	0.14646		0.02179	-0.06353		RAD. REF. PT. (X,Y)	0.0	0.0	
0.475	0.03204	0.14528		0.03204	-0.06598		INLET ANGLE (DEG.)	90.056		
0.500	0.04229	0.14326		0.04229	-0.06897		INLET WEDGE ANGLE (DEG.)	170.130		
0.525	0.05254	0.14037		0.05254	-0.07252		EXIT ANGLE (DEG.)	11.953		
0.550	0.06279	0.13660		0.06279	-0.07665		EXIT WEDGE ANGLE (DEG.)	5.146		
0.575	0.07304	0.13190		0.07304	-0.08138		UNCOVERED TURNING ANGLE (DEG.)	21.872		
0.600	0.08329	0.12624		0.08329	-0.08673		AXIAL CHORD	0.41000		
0.625	0.09354	0.11955		0.09354	-0.09276		ACTUAL CHORD	0.47938		
0.650	0.10379	0.11175		0.10379	-0.09948		PITCH	0.38686		
0.675	0.11404	0.10273		0.11404	-0.10696		NO. OF FOILS	84		
0.700	0.12429	0.09240		0.12429	-0.11525					
0.725	0.13454	0.08052		0.13454	-0.12443					
0.750	0.14479	0.06691		0.14479	-0.13459					
0.775	0.15504	0.05118		0.15504	-0.14584					
0.800	0.16529	0.03278		0.16529	-0.15838					
0.825	0.17554	0.01106		0.17554	-0.17239					
0.850	0.18579	-0.01479		0.18579	-0.18816					
0.875	0.19604	-0.04557		0.19604	-0.20616					
0.900	0.20629	-0.08202		0.20629	-0.22711					
0.910	0.21039	-0.09825		0.21039	-0.23668					
0.920	0.21449	-0.11544		0.21449	-0.24683					
0.930	0.21859	-0.13358		0.21859	-0.25768					
0.940	0.22269	-0.15266		0.22269	-0.27052					
0.950	0.22679	-0.17264		0.22679	-0.28604					
0.960	0.23089	-0.19346		0.23089	-0.30118	-0.29330				
0.970	0.23499	-0.21505		0.23499	-0.31264	-0.29519				
0.980	0.23909	-0.23740		0.23909	-0.31977	-0.29522				
0.990	0.24319	-0.26050		0.24319	-0.32254	-0.29339				
1.000	0.24729	-0.28437	-0.28523	0.24729	-0.32098	-0.28523				

NO. 1 CORL JNTOUR TITLE - ATD LOX 2V

TD 0 TD REV. 0 PART NO. EMD NO. DATE 11/18/87 TIME 12:20:23 CYLINDRICAL

SUBTITLE HOT RADIUS = 5.17200 COLD RADIUS = 0.0 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	-0.09781	0.00223	-0.00109	-0.09781	-0.02058	-0.00109				
0.010	-0.09544	0.00726		-0.09544	-0.01987	-0.00916				
0.020	-0.09307	0.01209		-0.09307	-0.01918	-0.01200				
0.030	-0.09070	0.01673		-0.09070	-0.01851	-0.01381				
0.040	-0.08833	0.02117		-0.08833	-0.01786	-0.01500				
0.050	-0.08596	0.02541		-0.08596	-0.01724	-0.01571				
0.060	-0.08360	0.02946		-0.08360	-0.01664	-0.01602				
0.070	-0.08123	0.03332		-0.08123	-0.01606	-0.01595	L.E. CIRCLE (X,Y,R)	-0.08286	-0.00109	0.01495
0.080	-0.07886	0.03699		-0.07886	-0.01551		T.E. CIRCLE (X,Y,R)	0.12421	-0.03547	0.01488
0.090	-0.07649	0.04047		-0.07649	-0.01498					
0.100	-0.07412	0.04378		-0.07412	-0.01447		L.E. TOP TANG. PT. (X,Y)	-0.09638	0.00530	
0.125	-0.06820	0.05139		-0.06820	-0.01330		L.E. BOTTOM TANG. PT. (X,Y)	-0.07949	-0.01565	
0.150	-0.06227	0.05815		-0.06227	-0.01227		T.E. TOP TANG. PT. (X,Y)	0.13821	-0.03042	
0.175	-0.05635	0.06424		-0.05635	-0.01138		T.E. BOTTOM TANG. PT. (X,Y)	0.11654	-0.04821	
0.200	-0.05043	0.06978		-0.05043	-0.01064					
0.225	-0.04451	0.07477		-0.04451	-0.01003		NOSE POINT (X,Y)	-0.09450	-0.01047	
0.250	-0.03859	0.07923		-0.03859	-0.00956		TAIL POINT (X,Y)	0.13365	-0.04497	
0.275	-0.03266	0.08314		-0.03266	-0.00923					
0.300	-0.02674	0.08653		-0.02674	-0.00904					
0.325	-0.02082	0.08941		-0.02082	-0.00898					
0.350	-0.01490	0.09181		-0.01490	-0.00906					
0.375	-0.00897	0.09373		-0.00897	-0.00928					
0.400	-0.00305	0.09519		-0.00305	-0.00963					
0.425	0.00287	0.09618		0.00287	-0.01013					
0.450	0.00879	0.09670		0.00879	-0.01076					
0.475	0.01472	0.09676		0.01472	-0.01153					
0.500	0.02064	0.09636		0.02064	-0.01244					
0.525	0.02656	0.09550		0.02656	-0.01350					
0.550	0.03248	0.09417		0.03248	-0.01469					
0.575	0.03841	0.09238		0.03841	-0.01603					
0.600	0.04433	0.09012		0.04433	-0.01751					
0.625	0.05025	0.08740		0.05025	-0.01914					
0.650	0.05617	0.08419		0.05617	-0.02092					
0.675	0.06210	0.08049		0.06210	-0.02285					
0.700	0.06802	0.07628		0.06802	-0.02494					
0.725	0.07394	0.07154		0.07394	-0.02718					
0.750	0.07986	0.06624		0.07986	-0.02958					
0.775	0.08579	0.06035		0.08579	-0.03214					
0.800	0.09171	0.05384		0.09171	-0.03487					
0.825	0.09763	0.04661		0.09763	-0.03777					
0.850	0.10355	0.03862		0.10355	-0.04084					
0.875	0.10948	0.02979		0.10948	-0.04409					
0.900	0.11540	0.02002		0.11540	-0.04753					
0.910	0.11777	0.01580		0.11777	-0.04896	-0.04888				
0.920	0.12014	0.01136		0.12014	-0.05042	-0.04978				
0.930	0.12251	0.00672		0.12251	-0.05191	-0.05025				
0.940	0.12488	0.00184		0.12488	-0.05343	-0.05033				
0.950	0.12724	-0.00327		0.12724	-0.05498	-0.05003				
0.960	0.12961	-0.00863		0.12961	-0.05657	-0.04933				
0.970	0.13198	-0.01425		0.13198	-0.05819	-0.04815				
0.980	0.13435	-0.02016		0.13435	-0.05984	-0.04636				
0.990	0.13672	-0.02637		0.13672	-0.06152	-0.04352				
1.000	0.13909	-0.03288	-0.03547	0.13909	-0.06324	-0.03547				

EXTERNAL CONTOUR TITLE - ATD LOX 2V

TD 0 TD REV. 0 PART NO. EMD NO. DATE 11/18/87 TIME 12:20:23 CYLINDRICAL

SUBTITLE HOT RADIUS = 5.33000 COLD RADIUS = 0.0 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	-0.15255	-0.02127	-0.02133	-0.15255	-0.02139	-0.02133				
0.010	-0.14836	0.00389		-0.14836	-0.04143					
0.020	-0.14417	0.01616		-0.14417	-0.04788					
0.030	-0.13998	0.02724		-0.13998	-0.05198					
0.040	-0.13579	0.03760		-0.13579	-0.05481					
0.050	-0.13160	0.04679		-0.13160	-0.05680					
0.060	-0.12741	0.05550		-0.12741	-0.05818					
0.070	-0.12322	0.06362		-0.12322	-0.05907		L.E. CIRCLE (X,Y,R)	-0.15039	-0.02133	0.00216
0.080	-0.11903	0.07122		-0.11903	-0.05955		T.E. CIRCLE (X,Y,R)	0.25655	-0.27518	0.00990
0.090	-0.11484	0.07833		-0.11484	-0.05970					
0.100	-0.11065	0.08501		-0.11065	-0.05954		L.E. TOP TANG. PT. (X,Y)	-0.15254	-0.02115	
0.125	-0.10017	0.10004		-0.10017	-0.05806		L.E. BOTTOM TANG. PT. (X,Y)	-0.15254	-0.02150	
0.150	-0.08970	0.11298		-0.08970	-0.05523		T.E. TOP TANG. PT. (X,Y)	0.26626	-0.27326	
0.175	-0.07923	0.12413		-0.07923	-0.05152		T.E. BOTTOM TANG. PT. (X,Y)	0.24703	-0.27792	
0.200	-0.06875	0.13373		-0.06875	-0.04822					
0.225	-0.05828	0.14192		-0.05828	-0.04549		NOSE POINT (X,Y)	-0.14192	-0.05054	
0.250	-0.04780	0.14882		-0.04780	-0.04333		TAIL POINT (X,Y)	0.25888	-0.28480	
0.275	-0.03733	0.15453		-0.03733	-0.04172					
0.300	-0.02685	0.15912		-0.02685	-0.04065		NET CROSS-SECT. AREA (EXCL. COATING)	0.05226		
0.325	-0.01638	0.16265		-0.01638	-0.04012					
0.350	-0.00590	0.16515		-0.00590	-0.04013		GAGING (X,Y,LAMBDA)	0.16151	0.06518	0.10161
0.375	0.00457	0.16667		0.00457	-0.04068		GAGING ANGLE (DEG.)	14.765		
0.400	0.01505	0.16723		0.01505	-0.04177					
0.425	0.02552	0.16683		0.02552	-0.04340		CTR. OF GRAV. (INCL. COATING) (X,Y)	0.06333	-0.00545	
0.450	0.03600	0.16549		0.03600	-0.04558		RAD. REF. PT. (X,Y)	0.0	0.0	
0.475	0.04647	0.16320		0.04647	-0.04833		INLET ANGLE (DEG.)	90.049		
0.500	0.05695	0.15995		0.05695	-0.05164		INLET WEDGE ANGLE (DEG.)	170.550		
0.525	0.06742	0.15573		0.06742	-0.05555		EXIT ANGLE (DEG.)	13.628		
0.550	0.07790	0.15051		0.07790	-0.06007		EXIT WEDGE ANGLE (DEG.)	4.876		
0.575	0.08837	0.14425		0.08837	-0.06522		UNCOVERED TURNING ANGLE (DEG.)	20.334		
0.600	0.09885	0.13691		0.09885	-0.07103		AXIAL CHORD	0.41900		
0.625	0.10932	0.12842		0.10932	-0.07754		ACTUAL CHORD	0.49169		
0.650	0.11980	0.11870		0.11980	-0.08478		PITCH	0.39868		
0.675	0.13027	0.10763		0.13027	-0.09280		NO. OF FOILS	84		
0.700	0.14075	0.09512		0.14075	-0.10167					
0.725	0.15122	0.08093		0.15122	-0.11146					
0.750	0.16170	0.06486		0.16170	-0.12225					
0.775	0.17217	0.04656		0.17217	-0.13415					
0.800	0.18265	0.02560		0.18265	-0.14735					
0.825	0.19312	0.00155		0.19312	-0.16201					
0.850	0.20360	-0.02599		0.20360	-0.17838					
0.875	0.21407	-0.05738		0.21407	-0.19688					
0.900	0.22455	-0.09290		0.22455	-0.21810					
0.910	0.22874	-0.10827		0.22874	-0.22750					
0.920	0.23293	-0.12429		0.23293	-0.23766					
0.930	0.23712	-0.14096		0.23712	-0.24873					
0.940	0.24131	-0.15826		0.24131	-0.26042					
0.950	0.24550	-0.17618		0.24550	-0.27282					
0.960	0.24969	-0.19469		0.24969	-0.28808	-0.28233				
0.970	0.25388	-0.21375		0.25388	-0.30842	-0.28472				
0.980	0.25807	-0.23335		0.25807	-0.33427	-0.28497				
0.990	0.26226	-0.25350		0.26226	-0.36565	-0.28327				
1.000	0.26645	-0.27420	-0.27518	0.26645	-0.40255	-0.27518				

NO. 1 CORL JNTOUR TITLE - ATD LOX 2V

TD 0 TD REV. 0 PART NO. EMD NO. DATE 11/18/87 TIME 12:20:23 CYLINDRICAL

SUBTITLE HOT RADIUS = 5.33000 COLD RADIUS = 0.0 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	-0.08805	0.02126	0.01796	-0.08805	-0.00176	0.01796				
0.010	-0.08573	0.02628		-0.08573	-0.00107	0.00991				
0.020	-0.08341	0.03111		-0.08341	-0.00041	0.00706				
0.030	-0.08109	0.03578		-0.08109	0.00025	0.00523				
0.040	-0.07877	0.04026		-0.07877	0.00089	0.00401				
0.050	-0.07645	0.04458		-0.07645	0.00151	0.00326				
0.060	-0.07414	0.04874		-0.07414	0.00211	0.00289				
0.070	-0.07182	0.05272		-0.07182	0.00268	0.00288	L.E. CIRCLE (X,Y,R)	-0.07293	0.01796	0.01512
0.080	-0.06950	0.05653		-0.06950	0.00323	0.00323	T.E. CIRCLE (X,Y,R)	0.12886	-0.01330	0.01499
0.090	-0.06718	0.06017		-0.06718	0.00376					
0.100	-0.06486	0.06364		-0.06486	0.00427		L.E. TOP TANG. PT. (X,Y)	-0.08664	0.02433	
0.125	-0.05906	0.07165		-0.05906	0.00544		L.E. BOTTOM TANG. PT. (X,Y)	-0.06949	0.00323	
0.150	-0.05326	0.07876		-0.05326	0.00647		T.E. TOP TANG. PT. (X,Y)	0.14264	-0.00740	
0.175	-0.04747	0.08514		-0.04747	0.00736		T.E. BOTTOM TANG. PT. (X,Y)	0.12141	-0.02632	
0.200	-0.04167	0.09087		-0.04167	0.00813					
0.225	-0.03587	0.09602		-0.03587	0.00875		NOSE POINT (X,Y)	-0.08466	0.00842	
0.250	-0.03007	0.10059		-0.03007	0.00925		TAIL POINT (X,Y)	0.13883	-0.02449	
0.275	-0.02428	0.10458		-0.02428	0.00961					
0.300	-0.01848	0.10801		-0.01848	0.00984					
0.325	-0.01268	0.11088		-0.01268	0.00994					
0.350	-0.00689	0.11321		-0.00689	0.00990					
0.375	-0.00109	0.11500		-0.00109	0.00973					
0.400	0.00471	0.11626		0.00471	0.00943					
0.425	0.01051	0.11701		0.01051	0.00900					
0.450	0.01630	0.11723		0.01630	0.00843					
0.475	0.02210	0.11694		0.02210	0.00773					
0.500	0.02790	0.11615		0.02790	0.00690					
0.525	0.03370	0.11486		0.03370	0.00593					
0.550	0.03949	0.11309		0.03949	0.00483					
0.575	0.04529	0.11084		0.04529	0.00358					
0.600	0.05109	0.10813		0.05109	0.00220					
0.625	0.05689	0.10495		0.05689	0.00068					
0.650	0.06268	0.10130		0.06268	-0.00098					
0.675	0.06848	0.09719		0.06848	-0.00278					
0.700	0.07428	0.09259		0.07428	-0.00473					
0.725	0.08008	0.08750		0.08008	-0.00683					
0.750	0.08587	0.08191		0.08587	-0.00908					
0.775	0.09167	0.07578		0.09167	-0.01148					
0.800	0.09747	0.06912		0.09747	-0.01404					
0.825	0.10327	0.06185		0.10327	-0.01675					
0.850	0.10906	0.05396		0.10906	-0.01963					
0.875	0.11486	0.04539		0.11486	-0.02267					
0.900	0.12066	0.03612		0.12066	-0.02589					
0.910	0.12298	0.03219		0.12298	-0.02722	-0.02710				
0.920	0.12530	0.02811		0.12530	-0.02858	-0.02787				
0.930	0.12762	0.02389		0.12762	-0.02997	-0.02824				
0.940	0.12994	0.01951		0.12994	-0.03139	-0.02826				
0.950	0.13225	0.01498		0.13225	-0.03284	-0.02791				
0.960	0.13457	0.01029		0.13457	-0.03432	-0.02716				
0.970	0.13689	0.00543		0.13689	-0.03582	-0.02596				
0.980	0.13921	0.00039		0.13921	-0.03736	-0.02414				
0.990	0.14153	-0.00483		0.14153	-0.03893	-0.02131				
1.000	0.14385	-0.01025	-0.01330	0.14385	-0.04053	-0.01330				

GRAPH PAPER ® GRAPHIC CONTROLS CORPORATION
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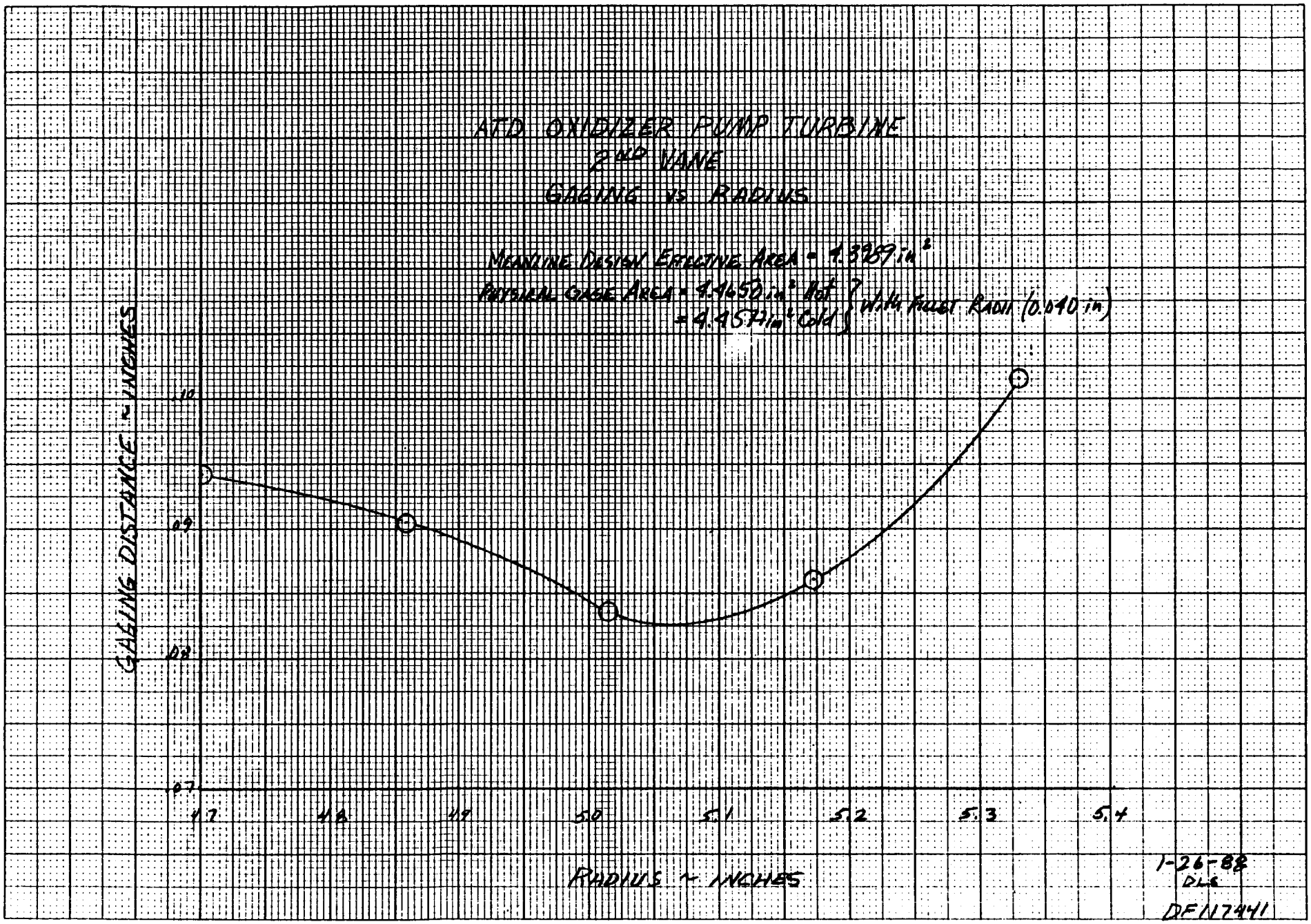
SQUARE 10 X 10 TO THE HALF INCH AS 0813 GO



P824 UTILITY PROGRAM - FLOW AREA CALCULATION

ATD LOX 2V
HOT TO COLD CONVERSION RADII

HOT	COLD
4.70000	4.69570
5.33000	5.32080

RESTAGGER ANGLE DEGREES = 0.0 RADIANS = 0.0
PLATFORM RADII LE ID = 0.0 LE OD = 0.0
TE ID = 0.0 TE OD = 0.0
GAGING RADII INNER = 4.70000 OUTER = 5.31406
NUMBER OF BLADES FOR GAGING = 84
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	3.71057	-18.98946	
-2.50000	3.85655	-15.80236	
-2.00000	4.00212	-12.62435	
-1.50000	4.14726	-9.45563	
-1.00000	4.29200	-6.29544	
-0.50000	4.43638	-3.14344	
0.0	4.58036	0.0	4.57314
0.50000	4.72396	3.13509	
1.00000	4.86718	6.26196	
1.50000	5.01000	9.38019	
2.00000	5.15244	12.48993	
2.50000	5.29449	15.59119	
3.00000	5.43612	18.68335	

IH0900I EXECUTION TERMINATING DUE TO ERROR COUNT FOR ERROR NUMBER 217

IHC171I FIOCS - END OF DATA SET ON UNIT 5

TRACEBACK	ROUTINE	CALLED FROM ISN	REG. 14	REG. 15	REG. 0	REG. 1
	IBCOM		00022E9C	00029A64	00000000	00081D46
	IPRNTF	0072	420220A0	000226D0	00046754	00020250
	MAIN		00EF1946	00020000	00000048	0E000DE0

ENTRY POINT= 00020000

SUMMARY OF ERRORS FOR THIS JOB

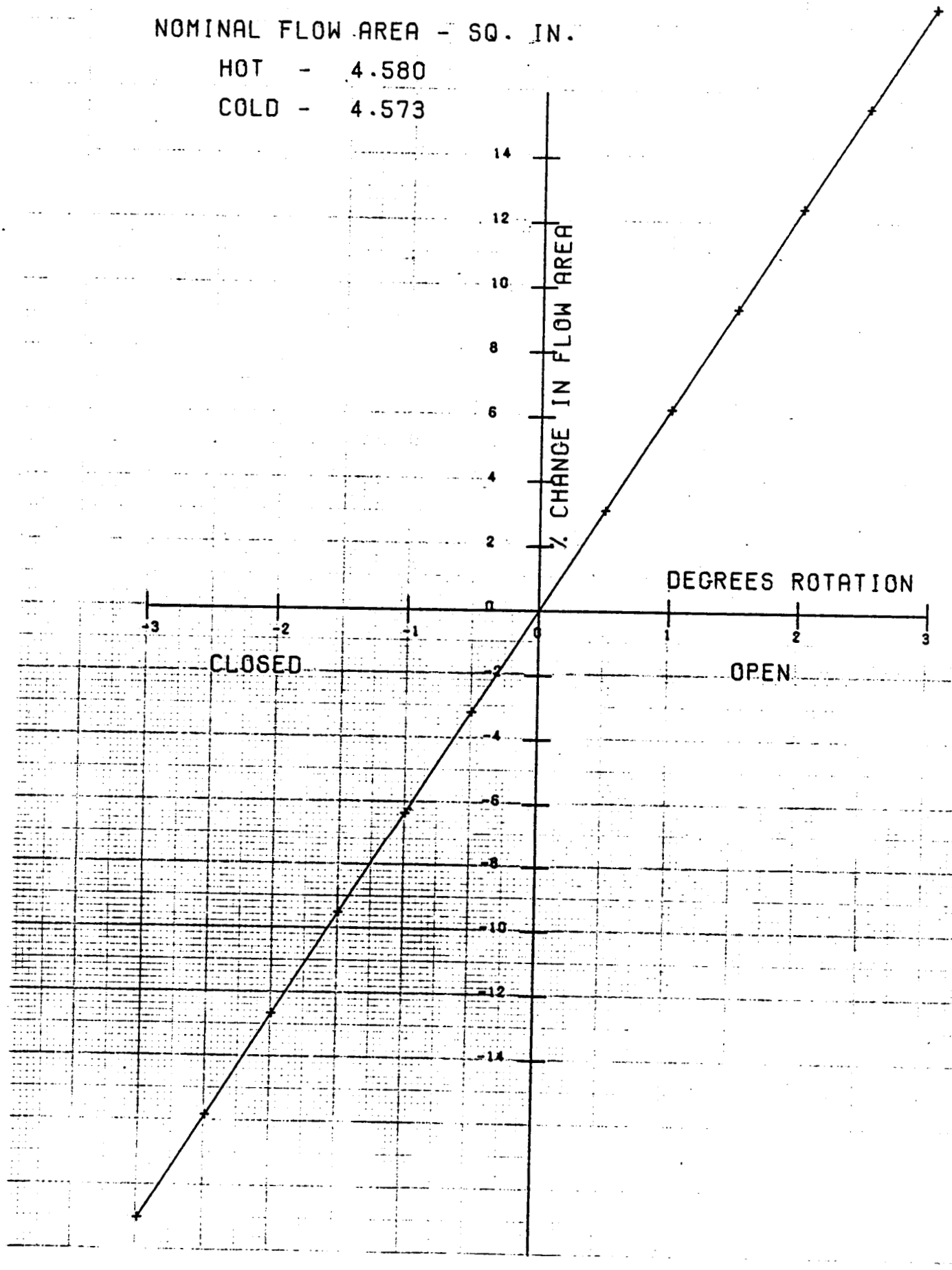
ERROR NUMBER	NUMBER OF ERRORS
217	1

ATD LOX 2V

NOMINAL FLOW AREA - SQ. IN.

HOT - 4.580

COLD - 4.573



P824 UTILITY PROGRAM - STRESS CALCULATION

ATD LOX 2V
ENGINE OPERATING CONDITION

	WAF	RPM	TITLE
1	66.0	0.	ADP 2V

XGBR = 0.00100 XGBM = 5.04166 XGBT = 20.23210
YGBR = 3.14285 YGBM = 23.11310 YGBT = 58.33929
DENSITY = 0.31200 WEIGHTING RADII INNER = 4.7000 OUTER = 5.3050
SHROUD VOLUME = 0.0 SHROUD THICKNESS = 0.0
SHROUD MISALIGNMENT = 0.0 RADIUS OF SHROUD = 0.0

ATD LOX 2V
DENSITY = 0.31200 WEIGHTING RADII INNER = 4.7000 OUTER = 5.3050
SHROUD VOLUME = 0.0 SHROUD THICKNESS = 0.0
SHROUD MISALIGNMENT = 0.0 RADIUS OF SHROUD = 0.0
WEIGHT OF AIRFOIL = 0.00943 WEIGHT OF SHROUD = 0.0
TOTAL WEIGHT = 0.79189 NUMBER OF BLADES = 84

SUMMARY OF SECTION PROPERTIES

%S	RADIUS	AREA	IMIN	IMAX	THETA	XBAR	YBAR
0	4.7000	0.0462	0.1954E-03	0.6663E-03	-34.67	-0.0000	0.0000
10	4.7605	0.0470	0.2042E-03	0.6951E-03	-34.59	0.0069	-0.0083
20	4.8210	0.0478	0.2145E-03	0.7265E-03	-34.46	0.0141	-0.0152
30	4.8815	0.0487	0.2266E-03	0.7599E-03	-34.27	0.0216	-0.0206
40	4.9420	0.0496	0.2400E-03	0.7936E-03	-34.08	0.0291	-0.0243
50	5.0025	0.0504	0.2531E-03	0.8253E-03	-33.96	0.0363	-0.0263
60	5.0630	0.0510	0.2639E-03	0.8535E-03	-33.98	0.0427	-0.0264
70	5.1235	0.0516	0.2709E-03	0.8787E-03	-34.13	0.0485	-0.0248
80	5.1840	0.0519	0.2740E-03	0.9016E-03	-34.39	0.0536	-0.0214
90	5.2445	0.0522	0.2731E-03	0.9221E-03	-34.75	0.0582	-0.0162
100	5.3050	0.0523	0.2687E-03	0.9388E-03	-35.22	0.0620	-0.0090

%S	RADIUS	K	L	MAX T	AX.WIDTH	C1	C2
0	4.7000	0.0	0.8850E-05	0.1576	0.3850	0.1260	0.1029
10	4.7605	0.0	0.9355E-05	0.1507	0.3886	0.1272	0.1058
20	4.8210	0.0	0.9867E-05	0.1452	0.3920	0.1286	0.1092
30	4.8815	0.0	0.1038E-04	0.1414	0.3953	0.1302	0.1130
40	4.9420	0.0	0.1090E-04	0.1391	0.3984	0.1319	0.1170
50	5.0025	0.0	0.1142E-04	0.1385	0.4014	0.1336	0.1205
60	5.0630	0.0	0.1195E-04	0.1399	0.4044	0.1352	0.1227
70	5.1235	0.0	0.1251E-04	0.1429	0.4075	0.1364	0.1236
80	5.1840	0.0	0.1310E-04	0.1477	0.4106	0.1374	0.1232
90	5.2445	0.0	0.1375E-04	0.1544	0.4140	0.1382	0.1217
100	5.3050	0.0	0.1444E-04	0.1629	0.4175	0.1388	0.1191

%S	RADIUS	C3	CLE	CTE	C4	ALPHA B	B
0	4.7000	0.1255	0.1464	0.2855	0.0523	61.34	0.4188
10	4.7605	0.1272	0.1495	0.2879	0.0544	61.15	0.4235
20	4.8210	0.1292	0.1528	0.2896	0.0571	60.95	0.4282
30	4.8815	0.1316	0.1561	0.2907	0.0483	60.78	0.4321
40	4.9420	0.1344	0.1592	0.2916	0.0518	60.60	0.4361
50	5.0025	0.1369	0.1619	0.2929	0.0428	60.43	0.4401
60	5.0630	0.1389	0.1639	0.2949	0.0450	60.27	0.4441
70	5.1235	0.1400	0.1653	0.2978	0.0461	60.13	0.4482
80	5.1840	0.1401	0.1661	0.3014	0.0461	60.00	0.4526
90	5.2445	0.1391	0.1663	0.3058	0.0574	59.87	0.4573
100	5.3050	0.1375	0.1655	0.3113	0.0550	59.75	0.4622

ATD LOX 2V
OPERATING CONDITION 1 ADP 2V
MAE = 66.0 MXR = 0.0 MXM = 5.0 MXT = 20.2
RPM = 0. MYR = 3.1 MYM = 23.1 MYT = 58.3

NET BENDING

%S	RADIUS	SIG P/A	SHRD P/A	LE	TE	CONV
0	4.7000	0.	0.	1722.	-165.	-1352.
10	4.7605	0.	0.	3217.	-147.	-2565.
20	4.8210	0.	0.	5067.	136.	-4132.
30	4.8815	0.	0.	7207.	665.	-5850.
40	4.9420	0.	0.	9592.	1409.	-7959.
50	5.0025	0.	0.	12232.	2333.	-10089.
60	5.0630	0.	0.	15202.	3435.	-12736.
70	5.1235	0.	0.	18585.	4748.	-15732.
80	5.1840	0.	0.	22474.	6317.	-19121.
90	5.2445	0.	0.	26987.	8172.	-23383.
100	5.3050	0.	0.	32260.	10294.	-27784.

GAS BENDING

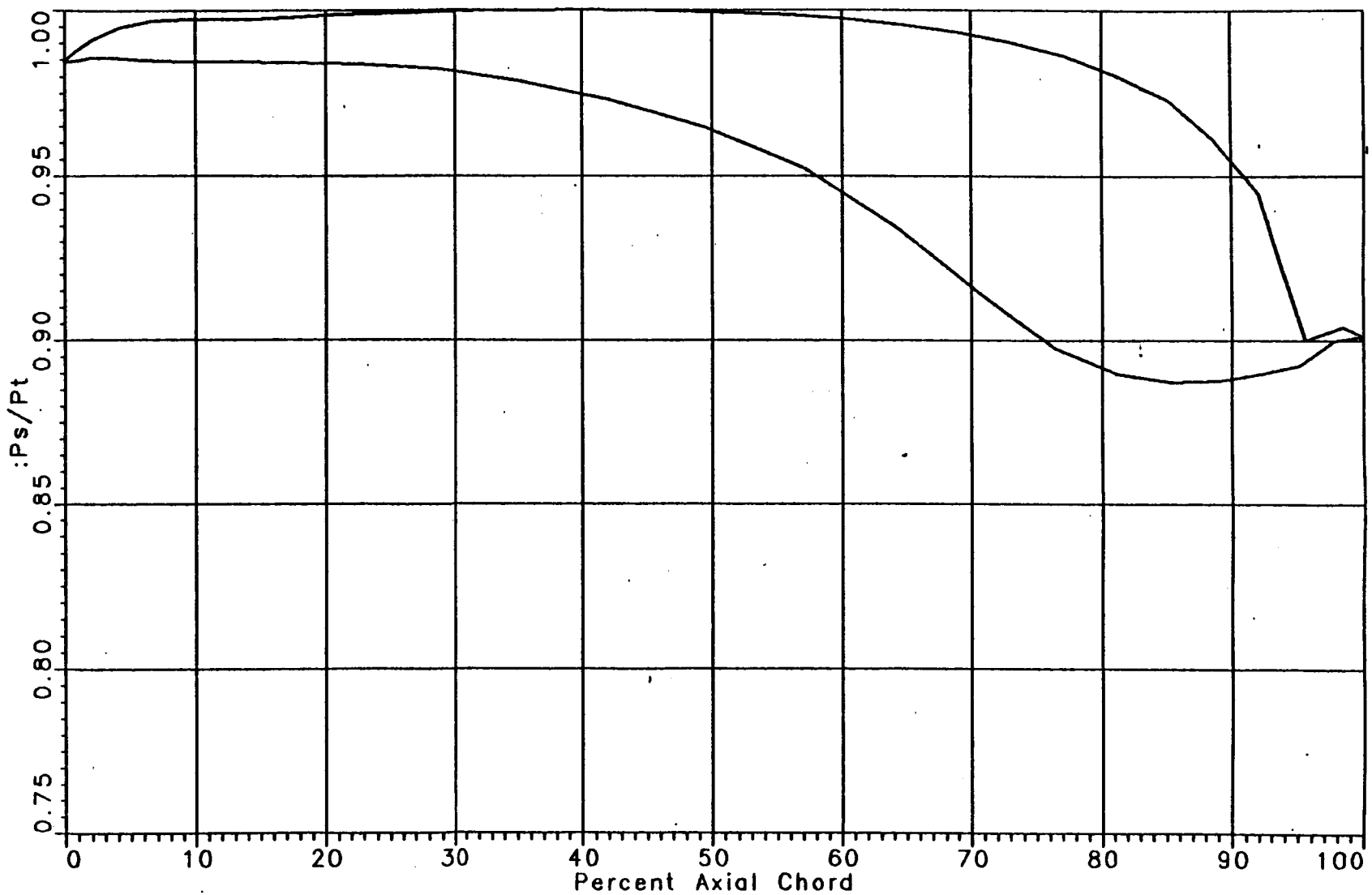
%S	RADIUS	XOFF	YOFF	LE	TE	CONV
0	4.7000	0.0	0.0	1722.	-165.	-1352.
10	4.7605	0.0069	-0.0083	3217.	-147.	-2565.
20	4.8210	0.0141	-0.0152	5067.	136.	-4132.
30	4.8815	0.0216	-0.0206	7207.	665.	-5850.
40	4.9420	0.0291	-0.0244	9592.	1409.	-7959.
50	5.0025	0.0363	-0.0263	12232.	2333.	-10089.
60	5.0630	0.0427	-0.0264	15202.	3435.	-12736.
70	5.1235	0.0485	-0.0248	18585.	4748.	-15732.
80	5.1840	0.0536	-0.0214	22474.	6317.	-19121.
90	5.2445	0.0582	-0.0162	26987.	8172.	-23383.
100	5.3050	0.0620	-0.0090	32260.	10294.	-27784.

SHROUD MISALIGNMENT

%S	RADIUS	AREA	PULL	LE	TE	CONV
0	4.7000	0.0462	0.0	0.	0.	0.
10	4.7605	0.0470	0.0	0.	0.	0.
20	4.8210	0.0478	0.0	0.	0.	0.
30	4.8815	0.0487	0.0	0.	0.	0.
40	4.9420	0.0496	0.0	0.	0.	0.
50	5.0025	0.0504	0.0	0.	0.	0.
60	5.0630	0.0510	0.0	0.	0.	0.
70	5.1235	0.0516	0.0	0.	0.	0.
80	5.1840	0.0519	0.0	0.	0.	0.
90	5.2445	0.0522	0.0	0.	0.	0.
100	5.3050	0.0523	0.0	0.	0.	0.

%S	RADIUS	MXT	MYT	MXG	MYG	THETA N
0	4.7000	0.0	0.0	0.0	3.1	0.02
10	4.7605	0.0	0.0	0.2	5.9	1.91
20	4.8210	0.0	0.0	0.8	9.3	4.91
30	4.8815	0.0	0.0	1.8	13.3	7.74
40	4.9420	0.0	0.0	3.2	17.9	10.20
50	5.0025	0.0	0.0	5.0	23.1	12.31
60	5.0630	0.0	0.0	7.3	28.9	14.10
70	5.1235	0.0	0.0	9.9	35.4	15.64
80	5.1840	0.0	0.0	12.9	42.4	16.96
90	5.2445	0.0	0.0	16.4	50.1	18.12
100	5.3050	0.0	0.0	20.2	58.3	19.13

PRATT & WHITNEY
SSME ATD Oxidizer Pump Turbine
Second Vane - 0% Span



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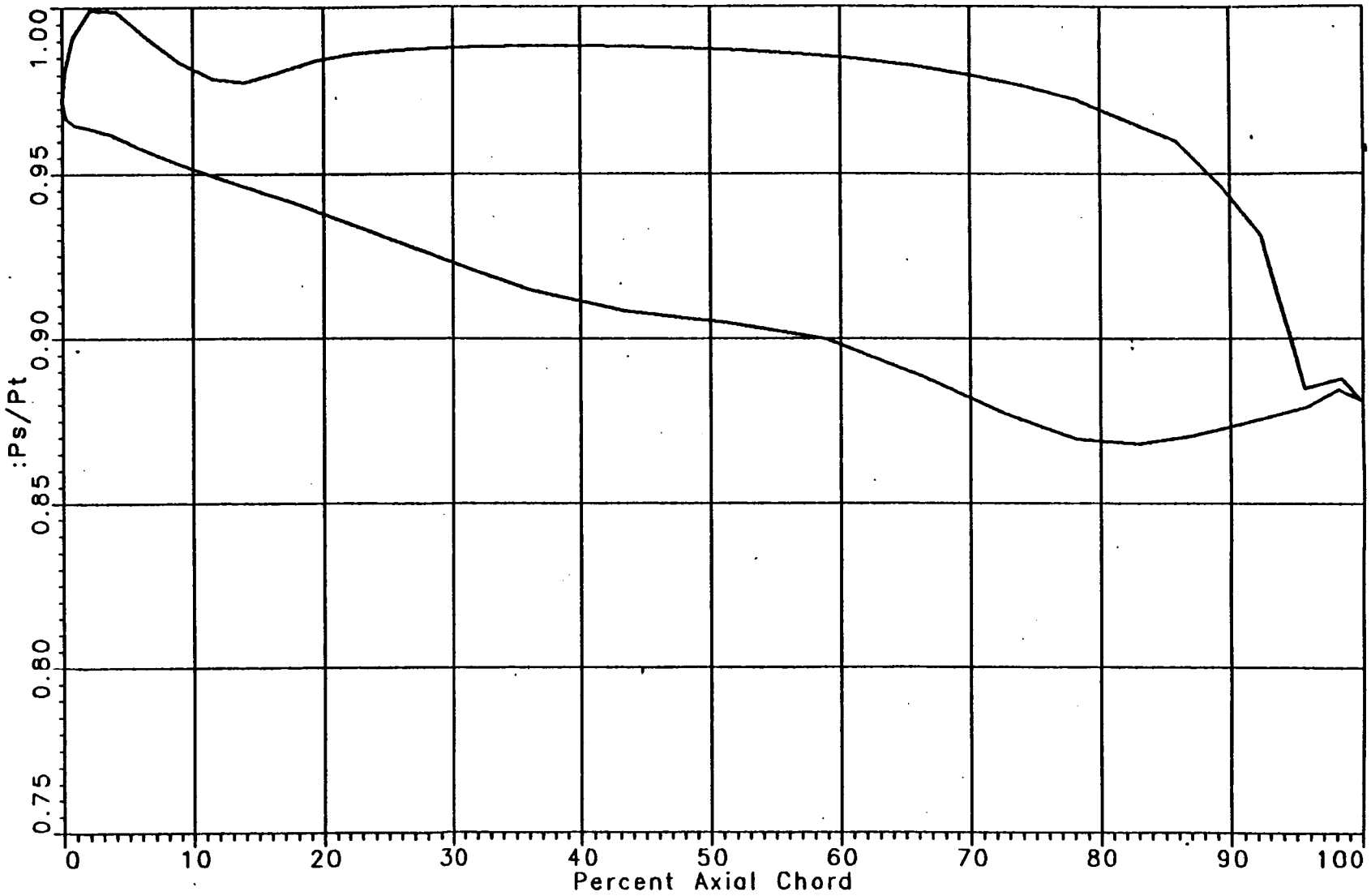
DLS

PRATT & WHITNEY
SSME ATD Oxidizer Pump Turbine
Second Vane - 25% Span



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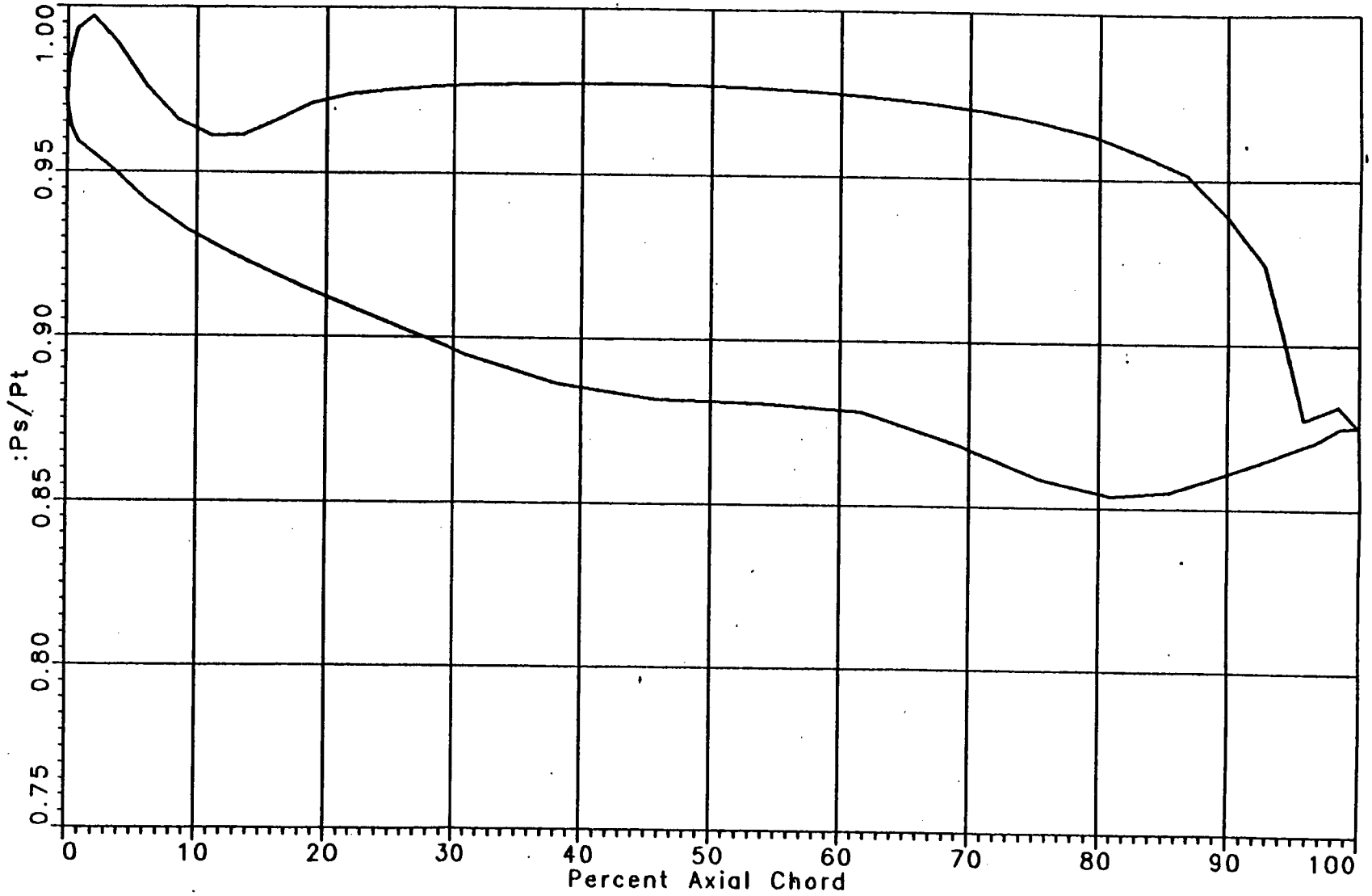
PRATT & WHITNEY
SSME ATD Oxidizer Pump Turbine
Second Vane - 50% Span



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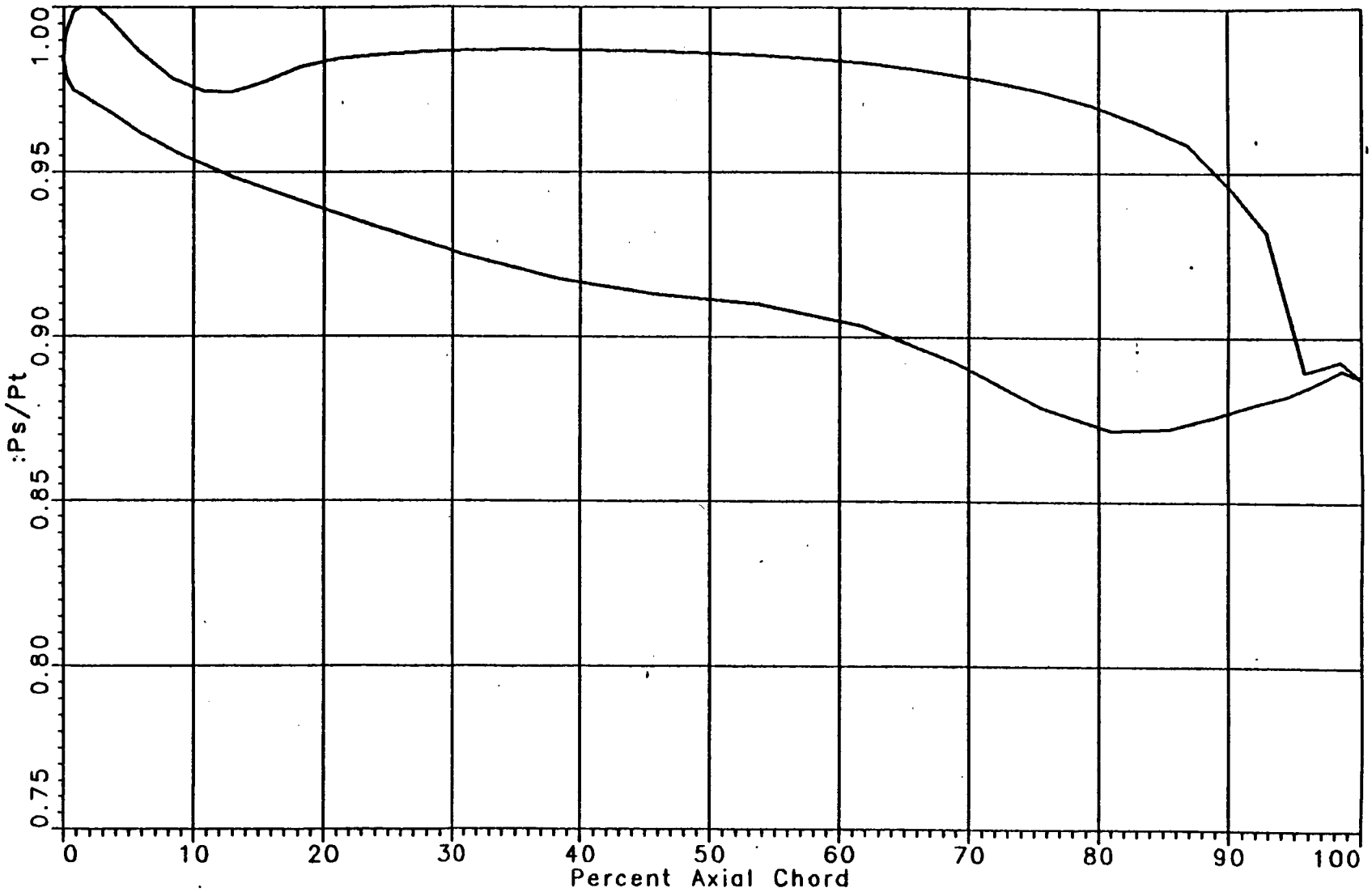
PRATT & WHITNEY
SSME ATD Oxidizer Pump Turbine
Second Vane - 75% Span



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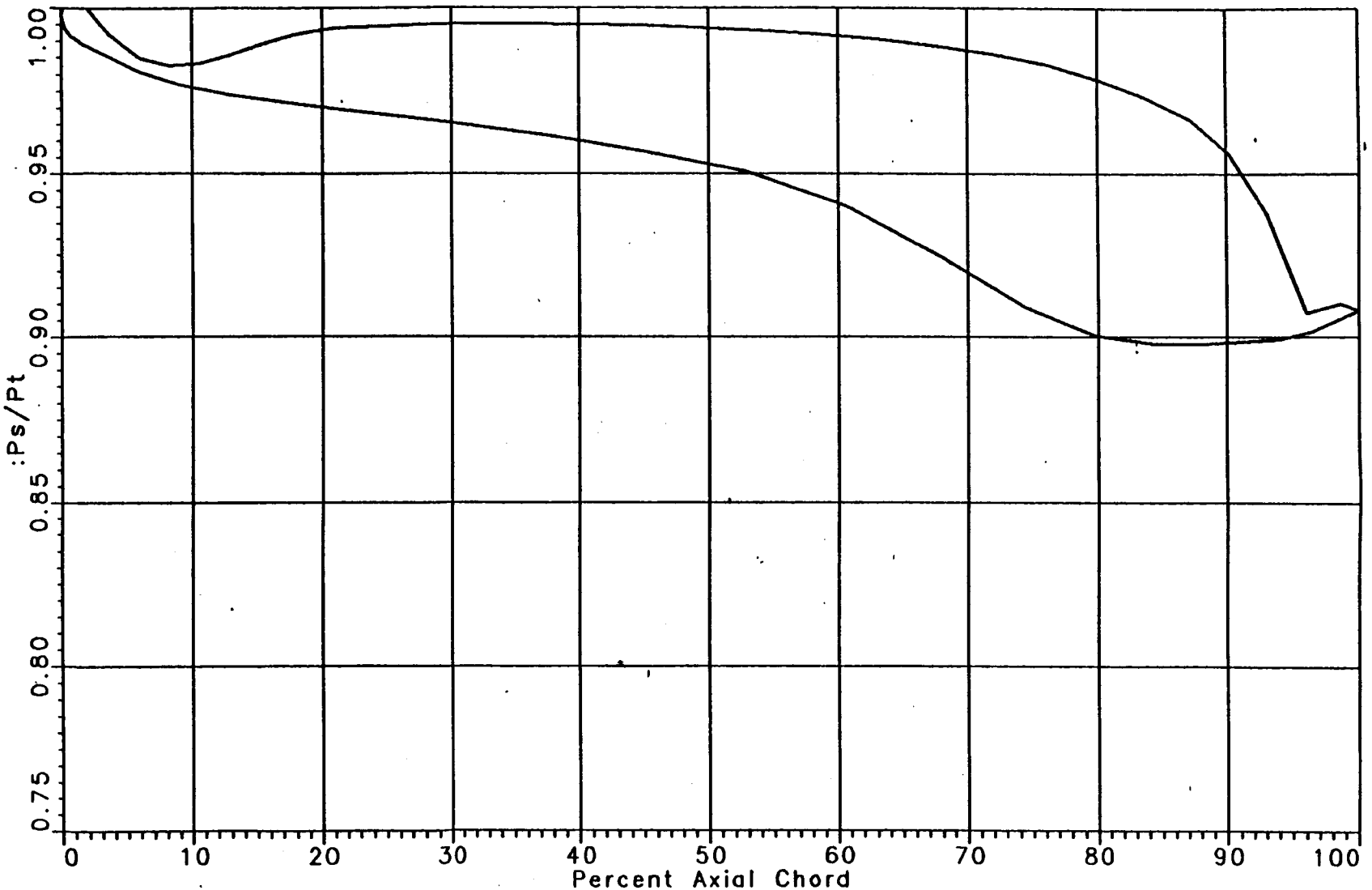
PRATT & WHITNEY
SSME ATD Oxidizer Pump Turbine
Second Vane - 100% Span



07/08/88
DLS

U456 — FINITE TRANSITION INTEGRAL BOUNDARY LAYER DECK

DATE 01/20/88 TIME 09:37:15

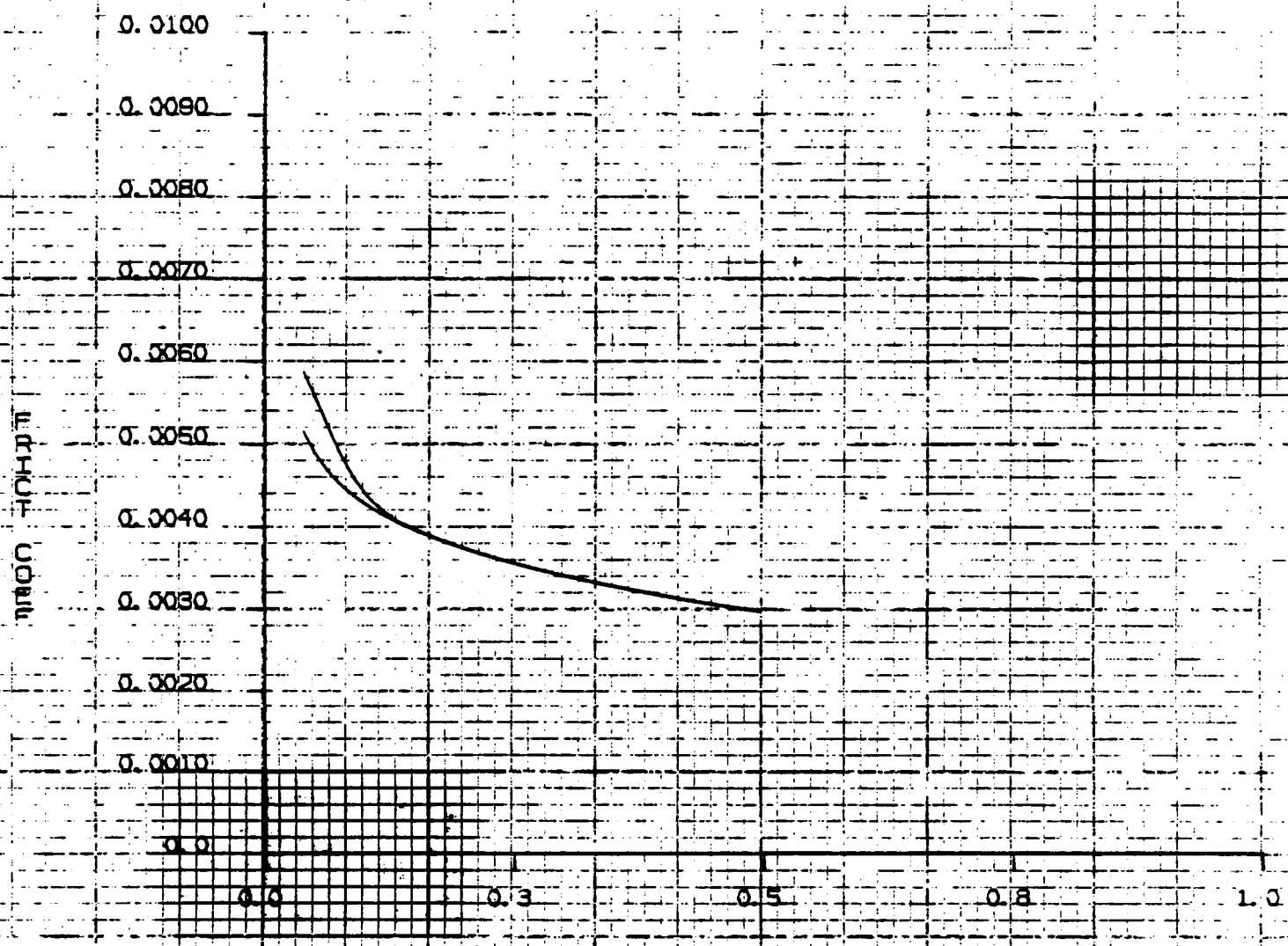
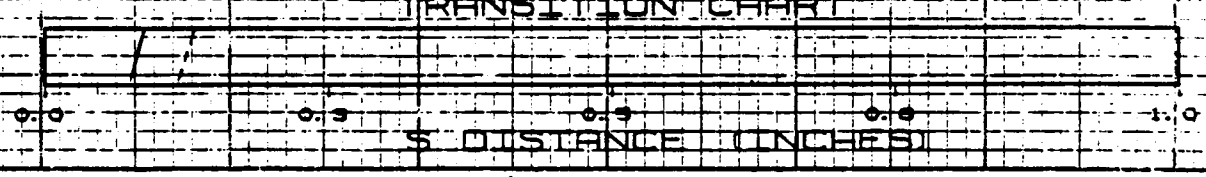
SSME ATD Oxidizer Pump Turbine - 2nd Vane - Mean Section

2.00% TU
10.00% TU

	INLET	EXIT
MACH NO.	0.154	0.386
GAS ANGLES	143.47	167.72

Suction Side

REF. REYNOLDS NO. 9913077.



TRANSITION CHART