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A TABULATION OF PIPE LENGTH TO DIAMETER RATIOS  
AS A FUNCTION OF MACH NUMBER AND  
PRESSURE RATIOS FOR COMPRESSIBLE FLOW.

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October 1975

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RATIOS AS A FUNCTION OF MACH NUMBER  
AND PRESSURE RATIOS FOR COMPRESSIBLE FLOW

By

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## SUMMARY

This paper presents computer programs and resulting tabulations of pipe line length to diameter ratios as a function of mach number and pressure ratios for compressible flow. Also presented are equations for the determination of weight flow.

Computer programs were developed utilizing the solutions of equations for isothermal flow with friction, and adiabatic flow with friction.

The programs, tabulations, and weight flow equations are applicable for air, nitrogen, oxygen and hydrogen.

The tabulations presented cover a wider range of Mach numbers for choked, adiabatic flow than available from commonly used engineering literatures. Additional information presented, but which is not available from this literature is (a) unchoked, adiabatic flow over a wide range of Mach numbers and (b) choked and unchoked isothermal flow for a wide range of Mach numbers.

## DESCRIPTION

The computer programs were developed utilizing the solutions to equations for isothermal flow with friction and adiabatic flow with friction. The first program produced the tabulation for length to diameter ratios as a function of Mach number and pressure ratios for compressible isothermal flow with friction. The second program produced the tabulation for length to diameter ratios as a function of Mach number and pressure ratios for compressible adiabatic flow with friction. The tabulations are applicable to air, nitrogen, oxygen and hydrogen.

Equations were also developed for the determination of weight flows.

## NOTATION - SYMBOLS AND DEFINITIONS

A	cross-sectional area, square inches
D	pipe inside diameter, inches
f	Fanning friction factor, dimensionless
K	ratio of gas specific heats, dimensionless
L	length of pipe, feet
$M_1$	Mach number at pipe entrance dimensionless
$P_1$	static pressure at pipe entrance, pounds per square inch
W	weight flow, pounds per second
$P_2$	static pressure at pipe exit, pounds per square inch
PL	limiting pressure for choked condition at end of pipe, pounds per square inch
R	gas constant, foot-pounds (force) per pound (mass) per degree Rankine
$T_2$	stream temperature at pipe exit, degrees Rankine
$T_1$	stream temperature at pipe entrance, degrees Rankine
$v_1$	specific volume at pipe entrance, cubic feet per pound
$v_2$	specific volume at pipe exit, cubic feet per pound

## INTRODUCTION

Isothermal flow with friction is of particular interest in connection with pipe lines transporting gases over long distances. Although the Mach numbers for such flows are usually quite low, there are substantial changes in pressure owing to the great lengths over which friction acts.

The material presented in this paper is limited to flows in which wall friction is the chief factor bringing about changes in fluid properties. It is assumed that no special attempt is made to transfer heat to or from the gas stream. When pipe lines are extremely short, the flow is approximately adiabatic. When the pipe lines are extremely long, there is sufficient area for heat transfer to make the flow nonadiabatic and approximately isothermal. The analysis performed in this paper is based on both cases.

For a given value of inlet Mach number, there is a maximum length for continuous isothermal or adiabatic flow (assuming the Mach number at the pipe exit equals unity). It is assumed that the back pressure to which the pipe exhausts is maintained as low as necessary, so that any diminishing of the flow is due exclusively to the limiting effects produced by friction. For subsonic flow an increase in the pipe length above its maximum value will act to decrease the inlet Mach number until a steady-state solution again becomes possible with the Mach number at the pipe exit equal to unity. This results in a reduction in flow rate, i.e., the flow is "choked" by friction.

## ANALYSIS

The equation (ref 1) for compressible flow pressure drop for isothermal flow with friction is:

$$\frac{L}{D} = \frac{1}{48fKM_1^2} \left[ 1 - \left( \frac{P_2}{P_1} \right)^2 \right] \quad (1)$$

$$- \frac{2}{48f} \log_e \left( \frac{P_1}{P_2} \right)$$

where:  $K = 1.4$  for air, nitrogen, oxygen, and hydrogen

$$f = 0.005$$



Equation (1) can be simplified to:

$$\frac{L}{D} = \frac{2.976}{M_1^2} \left[ 1 - \left( \frac{P_2}{P_1} \right)^2 \right] - 8.32 \log_e \left( \frac{P_1}{P_2} \right) \quad (2)$$

The equation (ref. 2) for length to diameter ratio for compressible adiabatic flow with friction is:

$$\frac{L}{D} = \frac{1}{(4)(12)f} \left\{ \left[ \frac{2 + (K-1) M_1^2}{2KM_1^2} \right] \left[ 1 - \left( \frac{v_1}{v_2} \right)^2 \right] - \left( \frac{K+1}{2k} \right) \log_e \left( \frac{v_2}{v_1} \right)^2 \right\} \quad (3)$$

where:  $k = 1.4$  for air, nitrogen, oxygen and hydrogen

$$f = 0.005$$

Equation (3) can be simplified to:

$$\frac{L}{D} = 2.976 \left\{ \frac{1 + 0.2 M_1^2}{M_1^2} \left[ 1 - \left( \frac{v_1}{v_2} \right)^2 \right] - 1.20 \log_e \left( \frac{v_2}{v_1} \right)^2 \right\} \quad (4)$$

$$\text{where: } \frac{P_2}{P_1} = \left( \frac{v_1}{v_2} \right) \left( \frac{T_2}{T_1} \right) \quad (5)$$

$$\text{and from ref. 2: } \frac{T_2}{T_1} = 1 - \left[ \left( \frac{k-1}{2} \right) M_1^2 \right] \left[ \left( \frac{v_2}{v_1} \right)^2 - 1 \right] \quad (6)$$

For  $K = 1.4$ , equation (6) can be simplified:

$$\frac{T_2}{T_1} = 1 - \left[ 0.2 M_1^2 \right] \left[ \left( \frac{v_2}{v_1} \right)^2 - 1 \right] \quad (7)$$

For the limiting conditions at the pipe exit (Mach number equals unity), the pressure ratio can be written (ref. 1) for isothermal compressible flow with friction:

$$\frac{P_L}{P_1} = (M_1)(K)^{1/2} \quad (8)$$

For the limiting conditions at the pipe exit (Mach number equals unity), the pressure ratio can be written (ref. 1) for adiabatic compressible flow with friction:

$$\frac{P_L}{P_1} = M_1^2 \left\{ \frac{K-1}{K+1} \left[ 1 + \frac{2}{(K-1) M_1^2} \right] \right\}^{1/2} \quad (9)$$

#### WEIGHT FLOW EQUATIONS

Listed below are the equations which may be used in conjunction with the tabulations for computation of gas weight flow:

$$W = \frac{0.722 P_1 D^2 M_1}{\sqrt{T_1}} \quad \text{FOR AIR} \quad (10)$$

$$W = \frac{0.709 P_1 D^2 M_1}{\sqrt{T_1}} \quad \text{FOR NITROGEN} \quad (11)$$

$$W = \frac{0.758 P_1 D^2 M_1}{\sqrt{T_1}} \quad \text{FOR OXYGEN} \quad (12)$$

$$W = \frac{0.189 P_1 D^2 M_1}{\sqrt{T_1}} \quad \text{FOR HYDROGEN} \quad (13)$$

The computer programs used in generating the tabulations of pipe line length to diameter ratios as a function of Mach number and pressure ratios for compressible flow are presented on the following pages.

The first program is for isothermal flow with friction. The second program is for adiabatic flow with friction. The programs and tabulations are valid for air, nitrogen, oxygen and hydrogen.

PROGRAM - COMPRESSIBLE ADIABATIC FLOW WITH FRICTION

```

PROGRAM FLJW(INPUT,OUTPUT,TAPE1=INPUT,TAPE2=OUTPUT)
000003 REAL K
000003 REAL MA(100)
000003 NAMELIST/NPUT/MA,K,F,NVALUE
000003 10 FORMAT(F10.5,F10.5,I3)
000003 20 FORMAT(6X,F8.5,7X,F10.4,7X,F15.9,10X,F15.9)
000003 21 FORMAT(1H0,///,* MACH NUMBER P2/P1 T2/T
.1 L/D (FEET/ INCHES) *,35X,*PAGE*,15,/,5X,
.11-***** ,10X,5H***** ,15X,5H***** ,12X,17H***** )
000003 25 FORMAT(1H1,* E N D O F J O B *)
000003 26 FORMAT(1H1, *K USED IN THESE CALCULATIONS WAS *,F10.5, * F
USED IN THESE CALCULATIONS WAS *,F10.5)
C PROGRAM WRITTEN FOR GRAYSON DIXON BY C. GRAY
C
C PROGRAM INPUT K AND F
C PROGRAM OUTPUT MACH NO.,T2/T1,P2/P1,L/D IN TABLE FORM
C
000003 1 CONTINUE
000003 IPAGE=0
000004 READ(1,NPUT)
000007 IF(EOF,1) 700,100
000012 100 CONTINUE
000012 WRITE(2,NPUT)
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
C
000015 DO 200 M=1,96
000017 AMACH=MA(M)
000020 PSTAR=AMACH**2 * SQRT((K-1.)/(K+1.)*(1.+2./((K-1.)*AMACH**2)))
000034 C=(K-1.)/2.*AMACH*AMACH
000040 P=1.
000041 ICOUNT=0
000042 IPAGE=IPAGE+1

```

```

000044 WRITE(2,26) K,F
000053 WRITE(2,21) IPAGE
C
C
C
C
C
C
C
C
C
C
000061 DO 300 J=1,200
000063 IF(P.LE.PSTAR)P=PSTAR
000066 V=(-P+SQRT(P**2+4.*(C+1.)*C))/(2.*C)
C
000101 T=P*V
C
000103 DL=((2.+(K-1.)*AMACH*AMACH)/(2.*AMACH*AMACH))*(1.-1./(V*V))*(1./K
2 )-(K+1.)/(2.*K)*ALOG(V*V)/(12.*F)
000135 IF(P.EQ.PSTAR)GOTO325
000137 WRITE(2,20) AMACH,P,T,DL
000153 P=P-.01
000155 ICOUNT=ICOUNT+1
000156 IF(ICOUNT.LT.40) GO TO 300
000161 IPAGE=IPAGE+1
000162 WRITE(2,26) K,F
000171 WRITE(2,21) IPAGE
000177 ICOUNT=0
000200 300 CONTINUE
000202 GOTO200
000203 325 WRITE(2,27)AMACH,P,T,DL
000217 27 FORMAT(6X,F8.5,7X,F10.4,7X,F15.9;10X,F15.9;5X,*MAX L/D - CHOKED FL
LOW CONDITION AT EXIT*)
C
C
C
C
C
C
C
C
C
000217 200 CONTINUE

```

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C  
C  
C  
C

000221 700 STOP  
000223 END

PROGRAM - COMPRESSIBLE ISOTHERMAL FLOW WITH FRICTION

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OF POOR QUALITY

```
PROGRAM ISOTH(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT)
C ISOTHERMAL COMPRESSIBLE FLOW OF GAS WITH FRICTION IN A PIPE
C L/D = 1.0/(48.0*F**K**2)*(1.0 - (P2/P1)**2) - 2.0/(48.0 * F)* LOGE(P1/P2)
C PL/P1 = M(SQRT. OF K)
C F = .005 (FANNING FRICTION FACTOR)
C K = 1.4
C D = PIPE DIA. (INCHES)
C L = PIPE LENGTH (FEET)
C P1 = STATIC PRESSURE AT PIPE ENTRANCE (PSIA)
C P2 = STATIC PRESSURE AT PIPE OUTLET (PSIA)
C PL = LIMITING P FOR CHOKED CONDITION AT PIPE OUTLET (PSIA)
C M = MACH NO. AT PIPE ENTRANCE
C T1 = GAS TEMPERATURE AT PIPE ENTRANCE (DEGREES R)
C L/D = XX
C P(1)/P(2) = Z(J)
C M(I)*1.4 **.5 = X(I)
000003 DIMENSION M(100),Y(100),Z(100),X(100),HEAD(7)
CC0003 REAL M
000003 NAMELIST /INPUT,NM,M,NY,Y
CC0003 READ(5,103)HEAD
000011 READ(5,INPUT)
000014 WRITE(6,INPUT)
000017 PRINT 103,HEAD
000025 103 FORMAT(1X,7A10)
000025 DO 100 I=1,NM
000027 PRINT 102
000032 X(I) = M(I) * 1.4**.5
000037 DO 101 J=1,NY
000041 Z(J) = 1.0/Y(J)
000043 IF(Y(J).LE.X(I)) GO TO 75
000046 XX = 2.976/M(I)**2 * (1.0 - Y(J)**2) - 8.33 * ALOG(Z(J))
000050 PRINT 105, M(I), Y(J), XX, X(I)
GG0073 101 CCNTINUE
000076 DO TO 100
000076 75 A = X(I)
0G0100 B = 1.0/A
000101 XX = 2.976/M(I)**2 * (1.0 - A**2) - 8.33 * ALOG(B)
000113 PRINT 106, M(I),A,XX
000124 100 CCNTINUE
G00127 106 FORMAT(6X,F6.3,3X,E12.3,3X,E12.3,5X,#MAX. L/D - CHCKED FLOW CONDIT
IONS AT EXIT*)
000127 105 FORMAT(6X,F6.3,8X,F5.2,4X,E12.3,4X,E12.3)
```



```
000127 102 FORMAT(1H1,9X,1FM,11X,5HP2/P1,9X,3HL/D,9X,9HM*1.4**5//)
000127 STOP
000131 END
```

Sample tabulations generated by the computer programs are presented on the following pages.

COMPRESSIBLE ISOTHERMAL FLOW WITH FRICTION  
SAMPLE TABULATION

M	P2/P1	L/D	M*1.4**5
.010	1.00	0.	1.183E-02
.010	.99	5.921E+02	1.183E-02
.010	.98	1.178E+03	1.183E-02
.010	.97	1.759E+03	1.183E-02
.010	.96	2.333E+03	1.183E-02
.010	.95	2.901E+03	1.183E-02
.010	.94	3.464E+03	1.183E-02
.010	.93	4.026E+03	1.183E-02
.010	.92	4.570E+03	1.183E-02
.010	.91	5.115E+03	1.183E-02
.010	.90	5.654E+03	1.183E-02
.010	.89	6.186E+03	1.183E-02
.010	.88	6.713E+03	1.183E-02
.010	.87	7.233E+03	1.183E-02
.010	.86	7.748E+03	1.183E-02
.010	.85	8.257E+03	1.183E-02
.010	.84	8.760E+03	1.183E-02
.010	.83	9.257E+03	1.183E-02
.010	.82	9.748E+03	1.183E-02
.010	.81	1.023E+04	1.183E-02
.010	.80	1.071E+04	1.183E-02
.010	.79	1.118E+04	1.183E-02
.010	.78	1.165E+04	1.183E-02
.010	.77	1.211E+04	1.183E-02
.010	.76	1.257E+04	1.183E-02
.010	.75	1.302E+04	1.183E-02
.010	.74	1.346E+04	1.183E-02
.010	.73	1.390E+04	1.183E-02
.010	.72	1.433E+04	1.183E-02
.010	.71	1.476E+04	1.183E-02
.010	.70	1.517E+04	1.183E-02
.010	.69	1.559E+04	1.183E-02
.010	.68	1.600E+04	1.183E-02
.010	.67	1.640E+04	1.183E-02
.010	.66	1.679E+04	1.183E-02
.010	.65	1.718E+04	1.183E-02
.010	.64	1.757E+04	1.183E-02
.010	.63	1.794E+04	1.183E-02
.010	.62	1.832E+04	1.183E-02
.010	.61	1.868E+04	1.183E-02
.010	.60	1.904E+04	1.183E-02
.010	.59	1.940E+04	1.183E-02
.010	.58	1.974E+04	1.183E-02
.010	.57	2.009E+04	1.183E-02
.010	.56	2.042E+04	1.183E-02
.010	.55	2.075E+04	1.183E-02

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.010	.54	2.140E+04	1.183E-02
.010	.53	2.140E+04	1.183E-02
.010	.52	2.171E+04	1.183E-02
.010	.51	2.201E+04	1.183E-02
.010	.50	2.231E+04	1.183E-02
.010	.49	2.261E+04	1.183E-02
.010	.48	2.290E+04	1.183E-02
.010	.47	2.318E+04	1.183E-02
.010	.46	2.346E+04	1.183E-02
.010	.45	2.373E+04	1.183E-02
.010	.44	2.399E+04	1.183E-02
.010	.43	2.425E+04	1.183E-02
.010	.42	2.450E+04	1.183E-02
.010	.41	2.475E+04	1.183E-02
.010	.40	2.499E+04	1.183E-02
.010	.39	2.523E+04	1.183E-02
.010	.38	2.545E+04	1.183E-02
.010	.37	2.566E+04	1.183E-02
.010	.36	2.589E+04	1.183E-02
.010	.35	2.611E+04	1.183E-02
.010	.34	2.631E+04	1.183E-02
.010	.33	2.651E+04	1.183E-02
.010	.32	2.670E+04	1.183E-02
.010	.31	2.689E+04	1.183E-02
.010	.30	2.707E+04	1.183E-02
.010	.29	2.725E+04	1.183E-02
.010	.28	2.742E+04	1.183E-02
.010	.27	2.758E+04	1.183E-02
.010	.26	2.774E+04	1.183E-02
.010	.25	2.789E+04	1.183E-02
.010	.24	2.803E+04	1.183E-02
.010	.23	2.817E+04	1.183E-02
.010	.22	2.831E+04	1.183E-02
.010	.21	2.843E+04	1.183E-02
.010	.20	2.856E+04	1.183E-02
.010	.19	2.867E+04	1.183E-02
.010	.18	2.878E+04	1.183E-02
.010	.17	2.889E+04	1.183E-02
.010	.16	2.898E+04	1.183E-02
.010	.15	2.907E+04	1.183E-02
.010	.14	2.916E+04	1.183E-02
.010	.13	2.924E+04	1.183E-02
.010	.12	2.931E+04	1.183E-02
.010	.11	2.938E+04	1.183E-02
.010	.10	2.944E+04	1.183E-02
.010	.09	2.950E+04	1.183E-02
.010	.08	2.955E+04	1.183E-02
.010	.07	2.959E+04	1.183E-02
.010	.06	2.963E+04	1.183E-02
.010	.05	2.966E+04	1.183E-02
.010	.04	2.969E+04	1.183E-02
.010	.03	2.972E+04	1.183E-02

.010	.D3	2.970E+04	1.183E-02
.010	.D2	2.972E+04	1.183E-02
.010	1.183E-02	2.972E+04	MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

M	P2/P1	L/D	M*1.4**5
.020	1.00	0.	2.366E-02
.020	.99	1.480E+02	2.366E-02
.020	.98	2.945E+02	2.366E-02
.020	.97	4.395E+02	2.366E-02
.020	.96	5.830E+02	2.366E-02
.020	.95	7.250E+02	2.366E-02
.020	.94	8.655E+02	2.366E-02
.020	.93	1.005E+03	2.366E-02
.020	.92	1.142E+03	2.366E-02
.020	.91	1.278E+03	2.366E-02
.020	.90	1.413E+03	2.366E-02
.020	.89	1.546E+03	2.366E-02
.020	.88	1.677E+03	2.366E-02
.020	.87	1.808E+03	2.366E-02
.020	.86	1.936E+03	2.366E-02
.020	.85	2.063E+03	2.366E-02
.020	.84	2.189E+03	2.366E-02
.020	.83	2.313E+03	2.366E-02
.020	.82	2.436E+03	2.366E-02
.020	.81	2.557E+03	2.366E-02
.020	.80	2.677E+03	2.366E-02
.020	.79	2.795E+03	2.366E-02
.020	.78	2.911E+03	2.366E-02
.020	.77	3.027E+03	2.366E-02
.020	.76	3.140E+03	2.366E-02
.020	.75	3.253E+03	2.366E-02
.020	.74	3.363E+03	2.366E-02
.020	.73	3.473E+03	2.366E-02
.020	.72	3.580E+03	2.366E-02
.020	.71	3.687E+03	2.366E-02
.020	.70	3.791E+03	2.366E-02
.020	.69	3.895E+03	2.366E-02
.020	.68	3.997E+03	2.366E-02
.020	.67	4.097E+03	2.366E-02
.020	.66	4.196E+03	2.366E-02
.020	.65	4.293E+03	2.366E-02
.020	.64	4.389E+03	2.366E-02
.020	.63	4.483E+03	2.366E-02
.020	.62	4.576E+03	2.366E-02
.020	.61	4.667E+03	2.366E-02
.020	.60	4.757E+03	2.366E-02
.020	.59	4.846E+03	2.366E-02
.020	.58	4.933E+03	2.366E-02
.020	.57	5.018E+03	2.366E-02
.020	.56	5.102E+03	2.366E-02
.020	.55	5.184E+03	2.366E-02
.020	.54	5.265E+03	2.366E-02

ORIGINAL PAGE IS  
OF POOR QUALITY

.020	.54	5.263E+03	2.366E-02
.020	.53	5.345E+03	2.366E-02
.020	.52	5.423E+03	2.366E-02
.020	.51	5.499E+03	2.366E-02
.020	.50	5.574E+03	2.366E-02
.020	.49	5.648E+03	2.366E-02
.020	.48	5.720E+03	2.366E-02
.020	.47	5.796E+03	2.366E-02
.020	.46	5.859E+03	2.366E-02
.020	.45	5.927E+03	2.366E-02
.020	.44	5.993E+03	2.366E-02
.020	.43	6.057E+03	2.366E-02
.020	.42	6.120E+03	2.366E-02
.020	.41	6.182E+03	2.366E-02
.020	.40	6.242E+03	2.366E-02
.020	.39	6.301E+03	2.366E-02
.020	.38	6.358E+03	2.366E-02
.020	.37	6.413E+03	2.366E-02
.020	.36	6.467E+03	2.366E-02
.020	.35	6.520E+03	2.366E-02
.020	.34	6.571E+03	2.366E-02
.020	.33	6.621E+03	2.366E-02
.020	.32	6.669E+03	2.366E-02
.020	.31	6.715E+03	2.366E-02
.020	.30	6.760E+03	2.366E-02
.020	.29	6.804E+03	2.366E-02
.020	.28	6.846E+03	2.366E-02
.020	.27	6.887E+03	2.366E-02
.020	.26	6.926E+03	2.366E-02
.020	.25	6.963E+03	2.366E-02
.020	.24	7.000E+03	2.366E-02
.020	.23	7.034E+03	2.366E-02
.020	.22	7.067E+03	2.366E-02
.020	.21	7.099E+03	2.366E-02
.020	.20	7.129E+03	2.366E-02
.020	.19	7.158E+03	2.366E-02
.020	.18	7.185E+03	2.366E-02
.020	.17	7.210E+03	2.366E-02
.020	.16	7.234E+03	2.366E-02
.020	.15	7.257E+03	2.366E-02
.020	.14	7.278E+03	2.366E-02
.020	.13	7.297E+03	2.366E-02
.020	.12	7.315E+03	2.366E-02
.020	.11	7.332E+03	2.366E-02
.020	.10	7.348E+03	2.366E-02
.020	.09	7.360E+03	2.366E-02
.020	.08	7.371E+03	2.366E-02
.020	.07	7.381E+03	2.366E-02
.020	.06	7.390E+03	2.366E-02
.020	.05	7.396E+03	2.366E-02
.020	.04	7.401E+03	2.366E-02



.020  
.020

.03  
2.366E-02

7.409E+03  
7.405E+03

2.366E-02  
MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

M	R2/P1	L/D	M#1.4**5
.030	1.00	0.	3.550E-02
.030	.99	6.572E+01	3.550E-02
.030	.98	1.308E+02	3.550E-02
.030	.97	1.952E+02	3.550E-02
.030	.96	2.589E+02	3.550E-02
.030	.95	3.220E+02	3.550E-02
.030	.94	3.844E+02	3.550E-02
.030	.93	4.461E+02	3.550E-02
.030	.92	5.072E+02	3.550E-02
.030	.91	5.676E+02	3.550E-02
.030	.90	6.274E+02	3.550E-02
.030	.89	6.865E+02	3.550E-02
.030	.88	7.449E+02	3.550E-02
.030	.87	8.027E+02	3.550E-02
.030	.86	8.598E+02	3.550E-02
.030	.85	9.162E+02	3.550E-02
.030	.84	9.720E+02	3.550E-02
.030	.83	1.027E+03	3.550E-02
.030	.82	1.082E+03	3.550E-02
.030	.81	1.135E+03	3.550E-02
.030	.80	1.189E+03	3.550E-02
.030	.79	1.241E+03	3.550E-02
.030	.78	1.293E+03	3.550E-02
.030	.77	1.344E+03	3.550E-02
.030	.76	1.394E+03	3.550E-02
.030	.75	1.444E+03	3.550E-02
.030	.74	1.493E+03	3.550E-02
.030	.73	1.542E+03	3.550E-02
.030	.72	1.590E+03	3.550E-02
.030	.71	1.637E+03	3.550E-02
.030	.70	1.683E+03	3.550E-02
.030	.69	1.729E+03	3.550E-02
.030	.68	1.774E+03	3.550E-02
.030	.67	1.819E+03	3.550E-02
.030	.66	1.863E+03	3.550E-02
.030	.65	1.906E+03	3.550E-02
.030	.64	1.949E+03	3.550E-02
.030	.63	1.990E+03	3.550E-02
.030	.62	2.032E+03	3.550E-02
.030	.61	2.072E+03	3.550E-02
.030	.60	2.112E+03	3.550E-02
.030	.59	2.151E+03	3.550E-02
.030	.58	2.190E+03	3.550E-02
.030	.57	2.228E+03	3.550E-02
.030	.56	2.265E+03	3.550E-02
.030	.55	2.301E+03	3.550E-02

ORIGINAL PAGE IS  
OF POOR QUALITY

.030	.54	2.357E+03	3.550E-02
.030	.53	2.373E+03	3.550E-02
.030	.52	2.407E+03	3.550E-02
.030	.51	2.441E+03	3.550E-02
.030	.50	2.474E+03	3.550E-02
.030	.49	2.507E+03	3.550E-02
.030	.48	2.539E+03	3.550E-02
.030	.47	2.570E+03	3.550E-02
.030	.46	2.601E+03	3.550E-02
.030	.45	2.630E+03	3.550E-02
.030	.44	2.660E+03	3.550E-02
.030	.43	2.688E+03	3.550E-02
.030	.42	2.716E+03	3.550E-02
.030	.41	2.743E+03	3.550E-02
.030	.40	2.770E+03	3.550E-02
.030	.39	2.796E+03	3.550E-02
.030	.38	2.821E+03	3.550E-02
.030	.37	2.846E+03	3.550E-02
.030	.36	2.870E+03	3.550E-02
.030	.35	2.893E+03	3.550E-02
.030	.34	2.915E+03	3.550E-02
.030	.33	2.937E+03	3.550E-02
.030	.32	2.959E+03	3.550E-02
.030	.31	2.979E+03	3.550E-02
.030	.30	2.999E+03	3.550E-02
.030	.29	3.018E+03	3.550E-02
.030	.28	3.037E+03	3.550E-02
.030	.27	3.055E+03	3.550E-02
.030	.26	3.072E+03	3.550E-02
.030	.25	3.088E+03	3.550E-02
.030	.24	3.104E+03	3.550E-02
.030	.23	3.120E+03	3.550E-02
.030	.22	3.134E+03	3.550E-02
.030	.21	3.148E+03	3.550E-02
.030	.20	3.161E+03	3.550E-02
.030	.19	3.173E+03	3.550E-02
.030	.18	3.185E+03	3.550E-02
.030	.17	3.196E+03	3.550E-02
.030	.16	3.207E+03	3.550E-02
.030	.15	3.216E+03	3.550E-02
.030	.14	3.225E+03	3.550E-02
.030	.13	3.234E+03	3.550E-02
.030	.12	3.241E+03	3.550E-02
.030	.11	3.248E+03	3.550E-02
.030	.10	3.254E+03	3.550E-02
.030	.09	3.260E+03	3.550E-02
.030	.08	3.264E+03	3.550E-02
.030	.07	3.266E+03	3.550E-02
.030	.06	3.271E+03	3.550E-02
.030	.05	3.273E+03	3.550E-02
.030	.04	3.275E+03	3.550E-02

MAX. FLOW CONDITIONS AT EXIT

M	P2/P1	L/D	M*1.4**0.5
.030	3.550E-02	3.275E+03	MAX. LTD - CHOKED FLOW CONDITIONS AT EXIT
.040	1.00	0.	4.733E-02
.040	.99	3.693E+01	4.733E-02
.040	.98	7.349E+01	4.733E-02
.040	.97	1.097E+02	4.733E-02
.040	.96	1.455E+02	4.733E-02
.040	.95	1.809E+02	4.733E-02
.040	.94	2.160E+02	4.733E-02
.040	.93	2.507E+02	4.733E-02
.040	.92	2.850E+02	4.733E-02
.040	.91	3.185E+02	4.733E-02
.040	.90	3.525E+02	4.733E-02
.040	.89	3.857E+02	4.733E-02
.040	.88	4.186E+02	4.733E-02
.040	.87	4.510E+02	4.733E-02
.040	.86	4.831E+02	4.733E-02
.040	.85	5.148E+02	4.733E-02
.040	.84	5.461E+02	4.733E-02
.040	.83	5.771E+02	4.733E-02
.040	.82	6.077E+02	4.733E-02
.040	.81	6.379E+02	4.733E-02
.040	.80	6.677E+02	4.733E-02
.040	.79	6.972E+02	4.733E-02
.040	.78	7.263E+02	4.733E-02
.040	.77	7.550E+02	4.733E-02
.040	.76	7.834E+02	4.733E-02
.040	.75	8.114E+02	4.733E-02
.040	.74	8.390E+02	4.733E-02
.040	.73	8.662E+02	4.733E-02
.040	.72	8.930E+02	4.733E-02
.040	.71	9.195E+02	4.733E-02
.040	.70	9.456E+02	4.733E-02
.040	.69	9.714E+02	4.733E-02
.040	.68	9.967E+02	4.733E-02
.040	.67	1.022E+03	4.733E-02
.040	.66	1.046E+03	4.733E-02
.040	.65	1.071E+03	4.733E-02
.040	.64	1.094E+03	4.733E-02
.040	.63	1.118E+03	4.733E-02
.040	.62	1.141E+03	4.733E-02
.040	.61	1.164E+03	4.733E-02
.040	.60	1.186E+03	4.733E-02
.040	.59	1.208E+03	4.733E-02
.040	.58	1.230E+03	4.733E-02
.040	.57	1.251E+03	4.733E-02
.040	.56	1.272E+03	4.733E-02
.040	.55	1.292E+03	4.733E-02

.040	.54	1.312E+03	4.733E-02
.040	.53	1.332E+03	4.733E-02
.040	.52	1.352E+03	4.733E-02
.040	.51	1.371E+03	4.733E-02
.040	.50	1.389E+03	4.733E-02
.040	.49	1.407E+03	4.733E-02
.040	.48	1.425E+03	4.733E-02
.040	.47	1.443E+03	4.733E-02
.040	.46	1.460E+03	4.733E-02
.040	.45	1.477E+03	4.733E-02
.040	.44	1.493E+03	4.733E-02
.040	.43	1.509E+03	4.733E-02
.040	.42	1.525E+03	4.733E-02
.040	.41	1.540E+03	4.733E-02
.040	.40	1.555E+03	4.733E-02
.040	.39	1.569E+03	4.733E-02
.040	.38	1.583E+03	4.733E-02
.040	.37	1.597E+03	4.733E-02
.040	.36	1.610E+03	4.733E-02
.040	.35	1.623E+03	4.733E-02
.040	.34	1.636E+03	4.733E-02
.040	.33	1.648E+03	4.733E-02
.040	.32	1.660E+03	4.733E-02
.040	.31	1.671E+03	4.733E-02
.040	.30	1.683E+03	4.733E-02
.040	.29	1.693E+03	4.733E-02
.040	.28	1.704E+03	4.733E-02
.040	.27	1.713E+03	4.733E-02
.040	.26	1.723E+03	4.733E-02
.040	.25	1.732E+03	4.733E-02
.040	.24	1.741E+03	4.733E-02
.040	.23	1.749E+03	4.733E-02
.040	.22	1.757E+03	4.733E-02
.040	.21	1.765E+03	4.733E-02
.040	.20	1.772E+03	4.733E-02
.040	.19	1.779E+03	4.733E-02
.040	.18	1.785E+03	4.733E-02
.040	.17	1.791E+03	4.733E-02
.040	.16	1.797E+03	4.733E-02
.040	.15	1.802E+03	4.733E-02
.040	.14	1.807E+03	4.733E-02
.040	.13	1.812E+03	4.733E-02
.040	.12	1.816E+03	4.733E-02
.040	.11	1.819E+03	4.733E-02
.040	.10	1.822E+03	4.733E-02
.040	.09	1.825E+03	4.733E-02
.040	.08	1.827E+03	4.733E-02
.040	.07	1.829E+03	4.733E-02
.040	.06	1.830E+03	4.733E-02
.040	.05	1.830E+03	4.733E-02
.040	4.733E-02	1.830E+03	MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

M	P2/P1	L/D	M*1.4**5
.050	1.00	0.	5.916E-02
.050	.99	2.361E+01	5.916E-02
.050	.98	4.697E+01	5.916E-02
.050	.97	7.010E+01	5.916E-02
.050	.96	9.299E+01	5.916E-02
.050	.95	1.156E+02	5.916E-02
.050	.94	1.380E+02	5.916E-02
.050	.93	1.602E+02	5.916E-02
.050	.92	1.822E+02	5.916E-02
.050	.91	2.038E+02	5.916E-02
.050	.90	2.253E+02	5.916E-02
.050	.89	2.465E+02	5.916E-02
.050	.88	2.675E+02	5.916E-02
.050	.87	2.882E+02	5.916E-02
.050	.86	3.087E+02	5.916E-02
.050	.85	3.290E+02	5.916E-02
.050	.84	3.490E+02	5.916E-02
.050	.83	3.686E+02	5.916E-02
.050	.82	3.883E+02	5.916E-02
.050	.81	4.076E+02	5.916E-02
.050	.80	4.267E+02	5.916E-02
.050	.79	4.455E+02	5.916E-02
.050	.78	4.641E+02	5.916E-02
.050	.77	4.824E+02	5.916E-02
.050	.76	5.005E+02	5.916E-02
.050	.75	5.184E+02	5.916E-02
.050	.74	5.360E+02	5.916E-02
.050	.73	5.534E+02	5.916E-02
.050	.72	5.706E+02	5.916E-02
.050	.71	5.875E+02	5.916E-02
.050	.70	6.041E+02	5.916E-02
.050	.69	6.206E+02	5.916E-02
.050	.68	6.367E+02	5.916E-02
.050	.67	6.527E+02	5.916E-02
.050	.66	6.684E+02	5.916E-02
.050	.65	6.839E+02	5.916E-02
.050	.64	6.991E+02	5.916E-02
.050	.63	7.141E+02	5.916E-02
.050	.62	7.288E+02	5.916E-02
.050	.61	7.433E+02	5.916E-02
.050	.60	7.576E+02	5.916E-02
.050	.59	7.716E+02	5.916E-02
.050	.58	7.854E+02	5.916E-02
.050	.57	7.990E+02	5.916E-02
.050	.56	8.123E+02	5.916E-02
.050	.55	8.253E+02	5.916E-02

.050	.54	8.581E+02	5.916E-02
.050	.53	8.507E+02	5.916E-02
.050	.52	8.631E+02	5.916E-02
.050	.51	8.752E+02	5.916E-02
.050	.50	8.870E+02	5.916E-02
.050	.49	8.986E+02	5.916E-02
.050	.48	9.100E+02	5.916E-02
.050	.47	9.212E+02	5.916E-02
.050	.46	9.320E+02	5.916E-02
.050	.45	9.427E+02	5.916E-02
.050	.44	9.531E+02	5.916E-02
.050	.43	9.633E+02	5.916E-02
.050	.42	9.732E+02	5.916E-02
.050	.41	9.829E+02	5.916E-02
.050	.40	9.923E+02	5.916E-02
.050	.39	1.001E+03	5.916E-02
.050	.38	1.010E+03	5.916E-02
.050	.37	1.019E+03	5.916E-02
.050	.36	1.028E+03	5.916E-02
.050	.35	1.036E+03	5.916E-02
.050	.34	1.044E+03	5.916E-02
.050	.33	1.052E+03	5.916E-02
.050	.32	1.059E+03	5.916E-02
.050	.31	1.066E+03	5.916E-02
.050	.30	1.073E+03	5.916E-02
.050	.29	1.080E+03	5.916E-02
.050	.28	1.086E+03	5.916E-02
.050	.27	1.093E+03	5.916E-02
.050	.26	1.099E+03	5.916E-02
.050	.25	1.104E+03	5.916E-02
.050	.24	1.110E+03	5.916E-02
.050	.23	1.115E+03	5.916E-02
.050	.22	1.120E+03	5.916E-02
.050	.21	1.125E+03	5.916E-02
.050	.20	1.129E+03	5.916E-02
.050	.19	1.134E+03	5.916E-02
.050	.18	1.138E+03	5.916E-02
.050	.17	1.141E+03	5.916E-02
.050	.16	1.145E+03	5.916E-02
.050	.15	1.148E+03	5.916E-02
.050	.14	1.151E+03	5.916E-02
.050	.13	1.153E+03	5.916E-02
.050	.12	1.156E+03	5.916E-02
.050	.11	1.158E+03	5.916E-02
.050	.10	1.159E+03	5.916E-02
.050	.09	1.161E+03	5.916E-02
.050	.08	1.162E+03	5.916E-02
.050	.07	1.162E+03	5.916E-02
.050	.06	1.163E+03	5.916E-02
.050	5.916E-02	1.163E+03	MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

M	P2/P1	L/D	M*1.4**5
.060	1.00	0.	7.059E-02
.060	.99	1.637E+01	7.059E-02
.060	.98	3.257E+01	7.059E-02
.060	.97	4.860E+01	7.059E-02
.060	.96	6.447E+01	7.059E-02
.060	.95	8.017E+01	7.059E-02
.060	.94	9.571E+01	7.059E-02
.060	.93	1.111E+02	7.059E-02
.060	.92	1.263E+02	7.059E-02
.060	.91	1.413E+02	7.059E-02
.060	.90	1.562E+02	7.059E-02
.060	.89	1.709E+02	7.059E-02
.060	.88	1.854E+02	7.059E-02
.060	.87	1.998E+02	7.059E-02
.060	.86	2.140E+02	7.059E-02
.060	.85	2.280E+02	7.059E-02
.060	.84	2.419E+02	7.059E-02
.060	.83	2.556E+02	7.059E-02
.060	.82	2.692E+02	7.059E-02
.060	.81	2.825E+02	7.059E-02
.060	.80	2.957E+02	7.059E-02
.060	.79	3.088E+02	7.059E-02
.060	.78	3.217E+02	7.059E-02
.060	.77	3.344E+02	7.059E-02
.060	.76	3.469E+02	7.059E-02
.060	.75	3.593E+02	7.059E-02
.060	.74	3.715E+02	7.059E-02
.060	.73	3.835E+02	7.059E-02
.060	.72	3.954E+02	7.059E-02
.060	.71	4.071E+02	7.059E-02
.060	.70	4.186E+02	7.059E-02
.060	.69	4.300E+02	7.059E-02
.060	.68	4.412E+02	7.059E-02
.060	.67	4.522E+02	7.059E-02
.060	.66	4.631E+02	7.059E-02
.060	.65	4.738E+02	7.059E-02
.060	.64	4.843E+02	7.059E-02
.060	.63	4.947E+02	7.059E-02
.060	.62	5.049E+02	7.059E-02
.060	.61	5.149E+02	7.059E-02
.060	.60	5.248E+02	7.059E-02
.060	.59	5.345E+02	7.059E-02
.060	.58	5.440E+02	7.059E-02
.060	.57	5.534E+02	7.059E-02
.060	.56	5.626E+02	7.059E-02
.060	.55	5.716E+02	7.059E-02

ORIGINAL PAGE IS OF POOR QUALITY



.060	.54	5.805E+02	7.099E-02
.060	.53	5.892E+02	7.099E-02
.060	.52	5.977E+02	7.099E-02
.060	.51	6.060E+02	7.099E-02
.060	.50	6.142E+02	7.099E-02
.060	.49	6.222E+02	7.099E-02
.060	.48	6.301E+02	7.099E-02
.060	.47	6.378E+02	7.099E-02
.060	.46	6.453E+02	7.099E-02
.060	.45	6.526E+02	7.099E-02
.060	.44	6.598E+02	7.099E-02
.060	.43	6.668E+02	7.099E-02
.060	.42	6.736E+02	7.099E-02
.060	.41	6.803E+02	7.099E-02
.060	.40	6.868E+02	7.099E-02
.060	.39	6.931E+02	7.099E-02
.060	.38	6.992E+02	7.099E-02
.060	.37	7.052E+02	7.099E-02
.060	.36	7.111E+02	7.099E-02
.060	.35	7.167E+02	7.099E-02
.060	.34	7.221E+02	7.099E-02
.060	.33	7.274E+02	7.099E-02
.060	.32	7.325E+02	7.099E-02
.060	.31	7.375E+02	7.099E-02
.060	.30	7.422E+02	7.099E-02
.060	.29	7.468E+02	7.099E-02
.060	.28	7.513E+02	7.099E-02
.060	.27	7.555E+02	7.099E-02
.060	.26	7.596E+02	7.099E-02
.060	.25	7.635E+02	7.099E-02
.060	.24	7.672E+02	7.099E-02
.060	.23	7.707E+02	7.099E-02
.060	.22	7.740E+02	7.099E-02
.060	.21	7.772E+02	7.099E-02
.060	.20	7.802E+02	7.099E-02
.060	.19	7.830E+02	7.099E-02
.060	.18	7.856E+02	7.099E-02
.060	.17	7.880E+02	7.099E-02
.060	.16	7.902E+02	7.099E-02
.060	.15	7.923E+02	7.099E-02
.060	.14	7.941E+02	7.099E-02
.060	.13	7.957E+02	7.099E-02
.060	.12	7.971E+02	7.099E-02
.060	.11	7.983E+02	7.099E-02
.060	.10	7.992E+02	7.099E-02
.060	.09	7.999E+02	7.099E-02
.060	.08	8.003E+02	7.099E-02
.060	7.099E-02	8.005E+02	MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

M	P2/P1	L/D	M*1.4**5
.070	1.00	0.	8.283E-02
.070	.99	1.200E+01	8.283E-02
.070	.98	2.388E+01	8.283E-02
.070	.97	3.564E+01	8.283E-02
.070	.96	4.728E+01	8.283E-02
.070	.95	5.879E+01	8.283E-02
.070	.94	7.018E+01	8.283E-02
.070	.93	8.145E+01	8.283E-02
.070	.92	9.259E+01	8.283E-02
.070	.91	1.036E+02	8.283E-02
.070	.90	1.145E+02	8.283E-02
.070	.89	1.253E+02	8.283E-02
.070	.88	1.360E+02	8.283E-02
.070	.87	1.465E+02	8.283E-02
.070	.86	1.569E+02	8.283E-02
.070	.85	1.672E+02	8.283E-02
.070	.84	1.774E+02	8.283E-02
.070	.83	1.874E+02	8.283E-02
.070	.82	1.973E+02	8.283E-02
.070	.81	2.071E+02	8.283E-02
.070	.80	2.168E+02	8.283E-02
.070	.79	2.263E+02	8.283E-02
.070	.78	2.358E+02	8.283E-02
.070	.77	2.451E+02	8.283E-02
.070	.76	2.543E+02	8.283E-02
.070	.75	2.633E+02	8.283E-02
.070	.74	2.723E+02	8.283E-02
.070	.73	2.811E+02	8.283E-02
.070	.72	2.898E+02	8.283E-02
.070	.71	2.983E+02	8.283E-02
.070	.70	3.068E+02	8.283E-02
.070	.69	3.151E+02	8.283E-02
.070	.68	3.233E+02	8.283E-02
.070	.67	3.314E+02	8.283E-02
.070	.66	3.393E+02	8.283E-02
.070	.65	3.472E+02	8.283E-02
.070	.64	3.549E+02	8.283E-02
.070	.63	3.624E+02	8.283E-02
.070	.62	3.699E+02	8.283E-02
.070	.61	3.772E+02	8.283E-02
.070	.60	3.844E+02	8.283E-02
.070	.59	3.915E+02	8.283E-02
.070	.58	3.985E+02	8.283E-02
.070	.57	4.053E+02	8.283E-02
.070	.56	4.121E+02	8.283E-02
.070	.55	4.186E+02	8.283E-02

.070	.54	4.291E+02	8.283E-02
.070	.53	4.315E+02	8.283E-02
.070	.52	4.377E+02	8.283E-02
.070	.51	4.438E+02	8.283E-02
.070	.50	4.497E+02	8.283E-02
.070	.49	4.556E+02	8.283E-02
.070	.48	4.613E+02	8.283E-02
.070	.47	4.669E+02	8.283E-02
.070	.46	4.724E+02	8.283E-02
.070	.45	4.777E+02	8.283E-02
.070	.44	4.829E+02	8.283E-02
.070	.43	4.880E+02	8.283E-02
.070	.42	4.930E+02	8.283E-02
.070	.41	4.978E+02	8.283E-02
.070	.40	5.025E+02	8.283E-02
.070	.39	5.071E+02	8.283E-02
.070	.38	5.116E+02	8.283E-02
.070	.37	5.159E+02	8.283E-02
.070	.36	5.201E+02	8.283E-02
.070	.35	5.242E+02	8.283E-02
.070	.34	5.282E+02	8.283E-02
.070	.33	5.320E+02	8.283E-02
.070	.32	5.357E+02	8.283E-02
.070	.31	5.392E+02	8.283E-02
.070	.30	5.427E+02	8.283E-02
.070	.29	5.460E+02	8.283E-02
.070	.28	5.491E+02	8.283E-02
.070	.27	5.522E+02	8.283E-02
.070	.26	5.551E+02	8.283E-02
.070	.25	5.578E+02	8.283E-02
.070	.24	5.605E+02	8.283E-02
.070	.23	5.630E+02	8.283E-02
.070	.22	5.653E+02	8.283E-02
.070	.21	5.676E+02	8.283E-02
.070	.20	5.696E+02	8.283E-02
.070	.19	5.716E+02	8.283E-02
.070	.18	5.734E+02	8.283E-02
.070	.17	5.750E+02	8.283E-02
.070	.16	5.765E+02	8.283E-02
.070	.15	5.779E+02	8.283E-02
.070	.14	5.791E+02	8.283E-02
.070	.13	5.801E+02	8.283E-02
.070	.12	5.809E+02	8.283E-02
.070	.11	5.816E+02	8.283E-02
.070	.10	5.821E+02	8.283E-02
.070	.09	5.824E+02	8.283E-02
.070	8.283E-02	5.824E+02	MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

M	P2/P1	L/D	M*1.4**5
.080	1.00	0.	9.466E-02
.080	.99	9.170E+00	9.466E-02
.080	.98	1.825E+01	9.466E-02
.080	.97	2.723E+01	9.466E-02
.080	.96	3.612E+01	9.466E-02
.080	.95	4.491E+01	9.466E-02
.080	.94	5.361E+01	9.466E-02
.080	.93	6.222E+01	9.466E-02
.080	.92	7.073E+01	9.466E-02
.080	.91	7.915E+01	9.466E-02
.080	.90	8.747E+01	9.466E-02
.080	.89	9.570E+01	9.466E-02
.080	.88	1.038E+02	9.466E-02
.080	.87	1.119E+02	9.466E-02
.080	.86	1.198E+02	9.466E-02
.080	.85	1.277E+02	9.466E-02
.080	.84	1.354E+02	9.466E-02
.080	.83	1.431E+02	9.466E-02
.080	.82	1.507E+02	9.466E-02
.080	.81	1.582E+02	9.466E-02
.080	.80	1.655E+02	9.466E-02
.080	.79	1.728E+02	9.466E-02
.080	.78	1.800E+02	9.466E-02
.080	.77	1.871E+02	9.466E-02
.080	.76	1.941E+02	9.466E-02
.080	.75	2.010E+02	9.466E-02
.080	.74	2.079E+02	9.466E-02
.080	.73	2.146E+02	9.466E-02
.080	.72	2.212E+02	9.466E-02
.080	.71	2.277E+02	9.466E-02
.080	.70	2.342E+02	9.466E-02
.080	.69	2.405E+02	9.466E-02
.080	.68	2.468E+02	9.466E-02
.080	.67	2.529E+02	9.466E-02
.080	.66	2.590E+02	9.466E-02
.080	.65	2.649E+02	9.466E-02
.080	.64	2.708E+02	9.466E-02
.080	.63	2.766E+02	9.466E-02
.080	.62	2.823E+02	9.466E-02
.080	.61	2.879E+02	9.466E-02
.080	.60	2.933E+02	9.466E-02
.080	.59	2.987E+02	9.466E-02
.080	.58	3.040E+02	9.466E-02
.080	.57	3.092E+02	9.466E-02
.080	.56	3.143E+02	9.466E-02
.080	.55	3.194E+02	9.466E-02

ORIGINAL PAGE IS  
OF POOR QUALITY

.080	.54	3.243E+02	9.466E-02
.080	.53	3.291E+02	9.466E-02
.080	.52	3.338E+02	9.466E-02
.080	.51	3.384E+02	9.466E-02
.080	.50	3.430E+02	9.466E-02
.080	.49	3.474E+02	9.466E-02
.080	.48	3.518E+02	9.466E-02
.080	.47	3.560E+02	9.466E-02
.080	.46	3.601E+02	9.466E-02
.080	.45	3.642E+02	9.466E-02
.080	.44	3.681E+02	9.466E-02
.080	.43	3.720E+02	9.466E-02
.080	.42	3.757E+02	9.466E-02
.080	.41	3.794E+02	9.466E-02
.080	.40	3.830E+02	9.466E-02
.080	.39	3.864E+02	9.466E-02
.080	.38	3.898E+02	9.466E-02
.080	.37	3.931E+02	9.466E-02
.080	.36	3.962E+02	9.466E-02
.080	.35	3.993E+02	9.466E-02
.080	.34	4.023E+02	9.466E-02
.080	.33	4.051E+02	9.466E-02
.080	.32	4.079E+02	9.466E-02
.080	.31	4.106E+02	9.466E-02
.080	.30	4.131E+02	9.466E-02
.080	.29	4.156E+02	9.466E-02
.080	.28	4.179E+02	9.466E-02
.080	.27	4.202E+02	9.466E-02
.080	.26	4.223E+02	9.466E-02
.080	.25	4.244E+02	9.466E-02
.080	.24	4.263E+02	9.466E-02
.080	.23	4.282E+02	9.466E-02
.080	.22	4.299E+02	9.466E-02
.080	.21	4.315E+02	9.466E-02
.080	.20	4.330E+02	9.466E-02
.080	.19	4.344E+02	9.466E-02
.080	.18	4.356E+02	9.466E-02
.080	.17	4.368E+02	9.466E-02
.080	.16	4.378E+02	9.466E-02
.080	.15	4.387E+02	9.466E-02
.080	.14	4.395E+02	9.466E-02
.080	.13	4.401E+02	9.466E-02
.080	.12	4.406E+02	9.466E-02
.080	.11	4.410E+02	9.466E-02
.080	.10	4.412E+02	9.466E-02
.080	9.466E-02	4.412E+02	MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

M	P2/P1	L/D	M*1.4** .5
.100	1.00	0.	1.183E-01
.100	.99	5.839E+00	1.183E-01
.100	.98	1.162E+01	1.183E-01
.100	.97	1.733E+01	1.183E-01
.100	.96	2.299E+01	1.183E-01
.100	.95	2.859E+01	1.183E-01
.100	.94	3.413E+01	1.183E-01
.100	.93	3.960E+01	1.183E-01
.100	.92	4.502E+01	1.183E-01
.100	.91	5.037E+01	1.183E-01
.100	.90	5.567E+01	1.183E-01
.100	.89	6.090E+01	1.183E-01
.100	.88	6.607E+01	1.183E-01
.100	.87	7.119E+01	1.183E-01
.100	.86	7.624E+01	1.183E-01
.100	.85	8.123E+01	1.183E-01
.100	.84	8.616E+01	1.183E-01
.100	.83	9.103E+01	1.183E-01
.100	.82	9.584E+01	1.183E-01
.100	.81	1.006E+02	1.183E-01
.100	.80	1.053E+02	1.183E-01
.100	.79	1.099E+02	1.183E-01
.100	.78	1.145E+02	1.183E-01
.100	.77	1.190E+02	1.183E-01
.100	.76	1.234E+02	1.183E-01
.100	.75	1.278E+02	1.183E-01
.100	.74	1.321E+02	1.183E-01
.100	.73	1.364E+02	1.183E-01
.100	.72	1.406E+02	1.183E-01
.100	.71	1.447E+02	1.183E-01
.100	.70	1.488E+02	1.183E-01
.100	.69	1.528E+02	1.183E-01
.100	.68	1.568E+02	1.183E-01
.100	.67	1.607E+02	1.183E-01
.100	.66	1.645E+02	1.183E-01
.100	.65	1.683E+02	1.183E-01
.100	.64	1.720E+02	1.183E-01
.100	.63	1.756E+02	1.183E-01
.100	.62	1.792E+02	1.183E-01
.100	.61	1.827E+02	1.183E-01
.100	.60	1.862E+02	1.183E-01
.100	.59	1.896E+02	1.183E-01
.100	.58	1.929E+02	1.183E-01
.100	.57	1.962E+02	1.183E-01
.100	.56	1.994E+02	1.183E-01
.100	.55	2.026E+02	1.183E-01

.100	.54	2.057E+02	1.183E-01
.100	.53	2.087E+02	1.183E-01
.100	.52	2.117E+02	1.183E-01
.100	.51	2.146E+02	1.183E-01
.100	.50	2.174E+02	1.183E-01
.100	.49	2.202E+02	1.183E-01
.100	.48	2.229E+02	1.183E-01
.100	.47	2.256E+02	1.183E-01
.100	.46	2.282E+02	1.183E-01
.100	.45	2.307E+02	1.183E-01
.100	.44	2.331E+02	1.183E-01
.100	.43	2.355E+02	1.183E-01
.100	.42	2.379E+02	1.183E-01
.100	.41	2.401E+02	1.183E-01
.100	.40	2.424E+02	1.183E-01
.100	.39	2.445E+02	1.183E-01
.100	.38	2.466E+02	1.182E-01
.100	.37	2.486E+02	1.183E-01
.100	.36	2.505E+02	1.183E-01
.100	.35	2.524E+02	1.183E-01
.100	.34	2.542E+02	1.183E-01
.100	.33	2.560E+02	1.183E-01
.100	.32	2.576E+02	1.183E-01
.100	.31	2.592E+02	1.183E-01
.100	.30	2.608E+02	1.183E-01
.100	.29	2.623E+02	1.183E-01
.100	.28	2.637E+02	1.183E-01
.100	.27	2.650E+02	1.183E-01
.100	.26	2.663E+02	1.183E-01
.100	.25	2.675E+02	1.183E-01
.100	.24	2.686E+02	1.183E-01
.100	.23	2.696E+02	1.183E-01
.100	.22	2.706E+02	1.183E-01
.100	.21	2.715E+02	1.183E-01
.100	.20	2.725E+02	1.182E-01
.100	.19	2.730E+02	1.183E-01
.100	.18	2.737E+02	1.183E-01
.100	.17	2.742E+02	1.183E-01
.100	.16	2.747E+02	1.183E-01
.100	.15	2.751E+02	1.183E-01
.100	.14	2.754E+02	1.183E-01
.100	.13	2.756E+02	1.183E-01
.100	.12	2.757E+02	1.183E-01
.100	1.183E-01	2.757E+02	MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

M	P2/P1	L/D	M*1.4**5
.120	1.00	0.	1.420E-01
.120	.99	4.029E+00	1.420E-01
.120	.98	8.016E+00	1.420E-01
.120	.97	1.196E+01	1.420E-01
.120	.96	1.586E+01	1.420E-01
.120	.95	1.972E+01	1.420E-01
.120	.94	2.354E+01	1.420E-01
.120	.93	2.732E+01	1.420E-01
.120	.92	3.105E+01	1.420E-01
.120	.91	3.474E+01	1.420E-01
.120	.90	3.839E+01	1.420E-01
.120	.89	4.200E+01	1.420E-01
.120	.88	4.556E+01	1.420E-01
.120	.87	4.908E+01	1.420E-01
.120	.86	5.256E+01	1.420E-01
.120	.85	5.600E+01	1.420E-01
.120	.84	5.939E+01	1.420E-01
.120	.83	6.274E+01	1.420E-01
.120	.82	6.605E+01	1.420E-01
.120	.81	6.932E+01	1.420E-01
.120	.80	7.254E+01	1.420E-01
.120	.79	7.572E+01	1.420E-01
.120	.78	7.886E+01	1.420E-01
.120	.77	8.196E+01	1.420E-01
.120	.76	8.501E+01	1.420E-01
.120	.75	8.802E+01	1.420E-01
.120	.74	9.099E+01	1.420E-01
.120	.73	9.391E+01	1.420E-01
.120	.72	9.679E+01	1.420E-01
.120	.71	9.963E+01	1.420E-01
.120	.70	1.024E+02	1.420E-01
.120	.69	1.052E+02	1.420E-01
.120	.68	1.079E+02	1.420E-01
.120	.67	1.106E+02	1.420E-01
.120	.66	1.132E+02	1.420E-01
.120	.65	1.158E+02	1.420E-01
.120	.64	1.183E+02	1.420E-01
.120	.63	1.208E+02	1.420E-01
.120	.62	1.232E+02	1.420E-01
.120	.61	1.256E+02	1.420E-01
.120	.60	1.280E+02	1.420E-01
.120	.59	1.303E+02	1.420E-01
.120	.58	1.326E+02	1.420E-01
.120	.57	1.348E+02	1.420E-01
.120	.56	1.370E+02	1.420E-01
.120	.55	1.392E+02	1.420E-01

ORIGINAL PAGE IS  
 OF POOR QUALITY



.120	.54	1.415E+02	1.420E-01
.120	.53	1.433E+02	1.420E-01
.120	.52	1.453E+02	1.420E-01
.120	.51	1.473E+02	1.420E-01
.120	.50	1.492E+02	1.420E-01
.120	.49	1.511E+02	1.420E-01
.120	.48	1.529E+02	1.420E-01
.120	.47	1.547E+02	1.420E-01
.120	.46	1.565E+02	1.420E-01
.120	.45	1.582E+02	1.420E-01
.120	.44	1.598E+02	1.420E-01
.120	.43	1.614E+02	1.420E-01
.120	.42	1.630E+02	1.420E-01
.120	.41	1.645E+02	1.420E-01
.120	.40	1.660E+02	1.420E-01
.120	.39	1.674E+02	1.420E-01
.120	.38	1.688E+02	1.420E-01
.120	.37	1.701E+02	1.420E-01
.120	.36	1.714E+02	1.420E-01
.120	.35	1.726E+02	1.420E-01
.120	.34	1.738E+02	1.420E-01
.120	.33	1.749E+02	1.420E-01
.120	.32	1.760E+02	1.420E-01
.120	.31	1.771E+02	1.420E-01
.120	.30	1.780E+02	1.420E-01
.120	.29	1.790E+02	1.420E-01
.120	.28	1.799E+02	1.420E-01
.120	.27	1.807E+02	1.420E-01
.120	.26	1.815E+02	1.420E-01
.120	.25	1.822E+02	1.420E-01
.120	.24	1.829E+02	1.420E-01
.120	.23	1.835E+02	1.420E-01
.120	.22	1.841E+02	1.420E-01
.120	.21	1.846E+02	1.420E-01
.120	.20	1.850E+02	1.420E-01
.120	.19	1.854E+02	1.420E-01
.120	.18	1.857E+02	1.420E-01
.120	.17	1.859E+02	1.420E-01
.120	.16	1.861E+02	1.420E-01
.120	.15	1.862E+02	1.420E-01
.120	1.420E-01	1.862E+02	MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

M	P2/P1	L/D	M*1.4**5
.140	1.00	0.	1.657E-01
.140	.99	2.938E+00	1.657E-01
.140	.98	5.844E+00	1.657E-01
.140	.97	8.720E+00	1.657E-01
.140	.96	1.156E+01	1.657E-01
.140	.95	1.438E+01	1.657E-01
.140	.94	1.711E+01	1.657E-01
.140	.93	1.991E+01	1.657E-01
.140	.92	2.263E+01	1.657E-01
.140	.91	2.532E+01	1.657E-01
.140	.90	2.797E+01	1.657E-01
.140	.89	3.060E+01	1.657E-01
.140	.88	3.319E+01	1.657E-01
.140	.87	3.575E+01	1.657E-01
.140	.86	3.828E+01	1.657E-01
.140	.85	4.078E+01	1.657E-01
.140	.84	4.325E+01	1.657E-01
.140	.83	4.568E+01	1.657E-01
.140	.82	4.809E+01	1.657E-01
.140	.81	5.046E+01	1.657E-01
.140	.80	5.280E+01	1.657E-01
.140	.79	5.511E+01	1.657E-01
.140	.78	5.739E+01	1.657E-01
.140	.77	5.964E+01	1.657E-01
.140	.76	6.185E+01	1.657E-01
.140	.75	6.403E+01	1.657E-01
.140	.74	6.618E+01	1.657E-01
.140	.73	6.830E+01	1.657E-01
.140	.72	7.039E+01	1.657E-01
.140	.71	7.244E+01	1.657E-01
.140	.70	7.447E+01	1.657E-01
.140	.69	7.646E+01	1.657E-01
.140	.68	7.841E+01	1.657E-01
.140	.67	8.034E+01	1.657E-01
.140	.66	8.224E+01	1.657E-01
.140	.65	8.410E+01	1.657E-01
.140	.64	8.593E+01	1.657E-01
.140	.63	8.772E+01	1.657E-01
.140	.62	8.949E+01	1.657E-01
.140	.61	9.122E+01	1.657E-01
.140	.60	9.292E+01	1.657E-01
.140	.59	9.459E+01	1.657E-01
.140	.58	9.622E+01	1.657E-01
.140	.57	9.782E+01	1.657E-01
.140	.56	9.939E+01	1.657E-01
.140	.55	1.009E+02	1.657E-01

.140	.53	1.039E+02	1.657E-01
.140	.52	1.053E+02	1.657E-01
.140	.51	1.067E+02	1.657E-01
.140	.50	1.081E+02	1.657E-01
.140	.49	1.094E+02	1.657E-01
.140	.48	1.107E+02	1.657E-01
.140	.47	1.120E+02	1.657E-01
.140	.46	1.132E+02	1.657E-01
.140	.45	1.144E+02	1.657E-01
.140	.44	1.156E+02	1.657E-01
.140	.43	1.167E+02	1.657E-01
.140	.42	1.178E+02	1.657E-01
.140	.41	1.189E+02	1.657E-01
.140	.40	1.199E+02	1.657E-01
.140	.39	1.209E+02	1.657E-01
.140	.38	1.219E+02	1.657E-01
.140	.37	1.228E+02	1.657E-01
.140	.36	1.236E+02	1.657E-01
.140	.35	1.245E+02	1.657E-01
.140	.34	1.253E+02	1.657E-01
.140	.33	1.261E+02	1.657E-01
.140	.32	1.268E+02	1.657E-01
.140	.31	1.275E+02	1.657E-01
.140	.30	1.281E+02	1.657E-01
.140	.29	1.288E+02	1.657E-01
.140	.28	1.293E+02	1.657E-01
.140	.27	1.299E+02	1.657E-01
.140	.26	1.304E+02	1.657E-01
.140	.25	1.308E+02	1.657E-01
.140	.24	1.312E+02	1.657E-01
.140	.23	1.316E+02	1.657E-01
.140	.22	1.319E+02	1.657E-01
.140	.21	1.321E+02	1.657E-01
.140	.20	1.324E+02	1.657E-01
.140	.19	1.325E+02	1.657E-01
.140	.18	1.326E+02	1.657E-01
.140	.17	1.327E+02	1.657E-01
.140	1.657E-01	1.327E+02	MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

ORIGINAL PAGE IS  
OF POOR QUALITY

M	P2/P1	L/D	M*1.4**5
.160	1.00	0.	1.893E-01
.160	.99	2.230E+00	1.893E-01
.160	.98	4.435E+00	1.893E-01
.160	.97	6.617E+00	1.893E-01
.160	.96	8.774E+00	1.893E-01
.160	.95	1.091E+01	1.893E-01
.160	.94	1.302E+01	1.893E-01
.160	.93	1.510E+01	1.893E-01
.160	.92	1.716E+01	1.893E-01
.160	.91	1.920E+01	1.893E-01
.160	.90	2.121E+01	1.893E-01
.160	.89	2.320E+01	1.893E-01
.160	.88	2.516E+01	1.893E-01
.160	.87	2.710E+01	1.893E-01
.160	.86	2.902E+01	1.893E-01
.160	.85	3.091E+01	1.893E-01
.160	.84	3.277E+01	1.893E-01
.160	.83	3.461E+01	1.893E-01
.160	.82	3.643E+01	1.893E-01
.160	.81	3.822E+01	1.893E-01
.160	.80	3.999E+01	1.893E-01
.160	.79	4.173E+01	1.893E-01
.160	.78	4.345E+01	1.893E-01
.160	.77	4.515E+01	1.893E-01
.160	.76	4.682E+01	1.893E-01
.160	.75	4.846E+01	1.893E-01
.160	.74	5.008E+01	1.893E-01
.160	.73	5.168E+01	1.893E-01
.160	.72	5.325E+01	1.893E-01
.160	.71	5.480E+01	1.893E-01
.160	.70	5.632E+01	1.893E-01
.160	.69	5.781E+01	1.893E-01
.160	.68	5.928E+01	1.893E-01
.160	.67	6.073E+01	1.893E-01
.160	.66	6.215E+01	1.893E-01
.160	.65	6.355E+01	1.893E-01
.160	.64	6.492E+01	1.893E-01
.160	.63	6.626E+01	1.893E-01
.160	.62	6.758E+01	1.893E-01
.160	.61	6.888E+01	1.893E-01
.160	.60	7.014E+01	1.893E-01
.160	.59	7.139E+01	1.893E-01
.160	.58	7.261E+01	1.893E-01
.160	.57	7.380E+01	1.893E-01
.160	.56	7.496E+01	1.893E-01
.160	.55	7.610E+01	1.893E-01
.160	.54	7.722E+01	1.893E-01
.160	.53	7.831E+01	1.893E-01

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.160	.55	7.037E+01	1.893E-01
.160	.52	7.937E+01	1.893E-01
.160	.51	8.040E+01	1.893E-01
.160	.50	8.141E+01	1.893E-01
.160	.49	8.240E+01	1.893E-01
.160	.48	8.335E+01	1.893E-01
.160	.47	8.428E+01	1.893E-01
.160	.46	8.518E+01	1.893E-01
.160	.45	8.606E+01	1.893E-01
.160	.44	8.691E+01	1.893E-01
.160	.43	8.773E+01	1.893E-01
.160	.42	8.852E+01	1.893E-01
.160	.41	8.928E+01	1.893E-01
.160	.40	9.002E+01	1.893E-01
.160	.39	9.072E+01	1.893E-01
.160	.38	9.140E+01	1.893E-01
.160	.37	9.205E+01	1.893E-01
.160	.36	9.267E+01	1.893E-01
.160	.35	9.326E+01	1.893E-01
.160	.34	9.383E+01	1.893E-01
.160	.33	9.436E+01	1.893E-01
.160	.32	9.485E+01	1.893E-01
.160	.31	9.532E+01	1.893E-01
.160	.30	9.576E+01	1.893E-01
.160	.29	9.616E+01	1.893E-01
.160	.28	9.653E+01	1.893E-01
.160	.27	9.687E+01	1.893E-01
.160	.26	9.717E+01	1.893E-01
.160	.25	9.744E+01	1.893E-01
.160	.24	9.767E+01	1.893E-01
.160	.23	9.786E+01	1.893E-01
.160	.22	9.801E+01	1.893E-01
.160	.21	9.812E+01	1.893E-01
.160	.20	9.819E+01	1.893E-01
.160	.19	9.822E+01	1.893E-01
.160	1.893E-01	9.822E+01	MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

M	P2/P1	L/D	M*1.4**0.5
.180	1.00	0.	2.130E-01
.180	.99	1.744E+00	2.130E-01
.180	.98	3.469E+00	2.130E-01
.180	.97	5.175E+00	2.130E-01
.180	.96	6.861E+00	2.130E-01
.180	.95	8.528E+00	2.130E-01
.180	.94	1.018E+01	2.130E-01
.180	.93	1.180E+01	2.130E-01
.180	.92	1.341E+01	2.130E-01
.180	.91	1.500E+01	2.130E-01
.180	.90	1.657E+01	2.130E-01
.180	.89	1.813E+01	2.130E-01
.180	.88	1.966E+01	2.130E-01
.180	.87	2.117E+01	2.130E-01
.180	.86	2.266E+01	2.130E-01
.180	.85	2.414E+01	2.130E-01
.180	.84	2.559E+01	2.130E-01
.180	.83	2.702E+01	2.130E-01
.180	.82	2.844E+01	2.130E-01
.180	.81	2.985E+01	2.130E-01
.180	.80	3.121E+01	2.130E-01
.180	.79	3.256E+01	2.130E-01
.180	.78	3.390E+01	2.130E-01
.180	.77	3.522E+01	2.130E-01
.180	.76	3.651E+01	2.130E-01
.180	.75	3.779E+01	2.130E-01
.180	.74	3.905E+01	2.130E-01
.180	.73	4.028E+01	2.130E-01
.180	.72	4.150E+01	2.130E-01
.180	.71	4.270E+01	2.130E-01
.180	.70	4.387E+01	2.130E-01
.180	.69	4.503E+01	2.130E-01
.180	.68	4.617E+01	2.130E-01
.180	.67	4.728E+01	2.130E-01
.180	.66	4.838E+01	2.130E-01
.180	.65	4.946E+01	2.130E-01
.180	.64	5.051E+01	2.130E-01
.180	.63	5.155E+01	2.130E-01
.180	.62	5.256E+01	2.130E-01
.180	.61	5.356E+01	2.130E-01
.180	.60	5.453E+01	2.130E-01
.180	.59	5.548E+01	2.130E-01
.180	.58	5.642E+01	2.130E-01
.180	.57	5.733E+01	2.130E-01
.180	.56	5.822E+01	2.130E-01
.180	.55	5.909E+01	2.130E-01
.180	.54	5.994E+01	2.130E-01
.180	.53	6.076E+01	2.130E-01

.180	.53	6.078E+01	2.130E-01
.180	.52	6.157E+01	2.130E-01
.180	.51	6.235E+01	2.130E-01
.180	.50	6.311E+01	2.130E-01
.180	.49	6.386E+01	2.130E-01
.180	.48	6.458E+01	2.130E-01
.180	.47	6.527E+01	2.130E-01
.180	.46	6.595E+01	2.130E-01
.180	.45	6.660E+01	2.130E-01
.180	.44	6.723E+01	2.130E-01
.180	.43	6.784E+01	2.130E-01
.180	.42	6.842E+01	2.130E-01
.180	.41	6.896E+01	2.130E-01
.180	.40	6.952E+01	2.130E-01
.180	.39	7.004E+01	2.130E-01
.180	.38	7.053E+01	2.130E-01
.180	.37	7.100E+01	2.130E-01
.180	.36	7.144E+01	2.130E-01
.180	.35	7.185E+01	2.130E-01
.180	.34	7.225E+01	2.130E-01
.180	.33	7.261E+01	2.130E-01
.180	.32	7.295E+01	2.130E-01
.180	.31	7.327E+01	2.130E-01
.180	.30	7.356E+01	2.130E-01
.180	.29	7.382E+01	2.130E-01
.180	.28	7.405E+01	2.130E-01
.180	.27	7.425E+01	2.130E-01
.180	.26	7.442E+01	2.130E-01
.180	.25	7.456E+01	2.130E-01
.180	.24	7.467E+01	2.130E-01
.180	.23	7.475E+01	2.130E-01
.180	.22	7.479E+01	2.130E-01
.180	2.130E-01	7.480E+01	MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

ORIGINAL PAGE IS  
OF POOR QUALITY

M	P2/P1	L/D	M*1.4**5
.200	1.00	0.	2.366E-01
.200	.99	1.397E+00	2.366E-01
.200	.98	2.778E+00	2.366E-01
.200	.97	4.143E+00	2.366E-01
.200	.96	5.493E+00	2.366E-01
.200	.95	6.827E+00	2.366E-01
.200	.94	8.145E+00	2.366E-01
.200	.93	9.447E+00	2.366E-01
.200	.92	1.073E+01	2.366E-01
.200	.91	1.200E+01	2.366E-01
.200	.90	1.326E+01	2.366E-01
.200	.89	1.450E+01	2.366E-01
.200	.88	1.572E+01	2.366E-01
.200	.87	1.693E+01	2.366E-01
.200	.86	1.812E+01	2.366E-01
.200	.85	1.929E+01	2.366E-01
.200	.84	2.045E+01	2.366E-01
.200	.83	2.159E+01	2.366E-01
.200	.82	2.272E+01	2.366E-01
.200	.81	2.383E+01	2.366E-01
.200	.80	2.493E+01	2.366E-01
.200	.79	2.600E+01	2.366E-01
.200	.78	2.707E+01	2.366E-01
.200	.77	2.811E+01	2.366E-01
.200	.76	2.914E+01	2.366E-01
.200	.75	3.015E+01	2.366E-01
.200	.74	3.115E+01	2.366E-01
.200	.73	3.213E+01	2.366E-01
.200	.72	3.309E+01	2.366E-01
.200	.71	3.404E+01	2.366E-01
.200	.70	3.497E+01	2.366E-01
.200	.69	3.589E+01	2.366E-01
.200	.68	3.678E+01	2.366E-01
.200	.67	3.767E+01	2.366E-01
.200	.66	3.853E+01	2.366E-01
.200	.65	3.938E+01	2.366E-01
.200	.64	4.021E+01	2.366E-01
.200	.63	4.102E+01	2.366E-01
.200	.62	4.182E+01	2.366E-01
.200	.61	4.260E+01	2.366E-01
.200	.60	4.336E+01	2.366E-01
.200	.59	4.411E+01	2.366E-01
.200	.58	4.483E+01	2.366E-01
.200	.57	4.554E+01	2.366E-01
.200	.56	4.624E+01	2.366E-01
.200	.55	4.691E+01	2.366E-01
.200	.54	4.757E+01	2.366E-01
.200	.53	4.821E+01	2.366E-01



.200	.53	4.821E+01	2.366E-01
.200	.52	4.884E+01	2.366E-01
.200	.51	4.944E+01	2.366E-01
.200	.50	5.005E+01	2.366E-01
.200	.49	5.059E+01	2.366E-01
.200	.48	5.114E+01	2.366E-01
.200	.47	5.168E+01	2.366E-01
.200	.46	5.219E+01	2.366E-01
.200	.45	5.268E+01	2.366E-01
.200	.44	5.316E+01	2.366E-01
.200	.43	5.361E+01	2.366E-01
.200	.42	5.405E+01	2.366E-01
.200	.41	5.447E+01	2.366E-01
.200	.40	5.486E+01	2.366E-01
.200	.39	5.524E+01	2.366E-01
.200	.38	5.560E+01	2.366E-01
.200	.37	5.593E+01	2.366E-01
.200	.36	5.625E+01	2.366E-01
.200	.35	5.654E+01	2.366E-01
.200	.34	5.681E+01	2.366E-01
.200	.33	5.706E+01	2.366E-01
.200	.32	5.729E+01	2.366E-01
.200	.31	5.749E+01	2.366E-01
.200	.30	5.767E+01	2.366E-01
.200	.29	5.783E+01	2.366E-01
.200	.28	5.796E+01	2.366E-01
.200	.27	5.807E+01	2.366E-01
.200	.26	5.815E+01	2.366E-01
.200	.25	5.820E+01	2.366E-01
.200	.24	5.823E+01	2.366E-01
.200	2.366E-01	5.823E+01	MAX. L/D - CHOKED FLOW CONDITIONS AT EXIT

## COMPRESSIBLE ADIABATIC FLOW WITH FRICTION

## SAMPLE TABULATION

PRECEDING PAGE BLANK NOT FILMED

K USED IN THESE CALCULATIONS WAS

1.40000

F USED IN THESE CALCULATIONS WAS

.02000

YACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE	1
*****	*****	*****	*****		
.01000	1.0000	1.000000000	-.000002253		
.01000	.9900	.99999594	592.178271282		
.01000	.9800	.99999175	1178.403555352		
.01000	.9700	.99998744	1758.675834692		
.01000	.9600	.99998299	2332.995093328		
.01000	.9500	.99997839	2901.361313004		
.01000	.9400	.99997365	3463.774480508		
.01000	.9300	.99996876	4020.234577487		
.01000	.9200	.99996371	4570.741586013		
.01000	.9100	.99995848	5115.295491121		
.01000	.9000	.99995309	5653.896269382		
.01000	.8900	.99994751	6186.543907443		
.01000	.8800	.99994174	6713.238378450		
.01000	.8700	.99993577	7233.979664897		
.01000	.8600	.99992959	7748.767749006		
.01000	.8500	.99992319	8257.602605334		
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.01000	.8300	.99990969	9257.412538057		
.01000	.8200	.99990256	9748.387569198		
.01000	.8100	.99989517	10233.409277675		
.01000	.8000	.99988751	10712.477635357		
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.01000	.7600	.99985375	12569.216996919		
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.01000	.6100	.99966255	18683.595830420		

ORIGINAL PAGE IS  
OF POOR QUALITY

K USED IN THESE CALCULATIONS WAS

1.40000

F USED IN THESE CALCULATIONS WAS

.02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE
*****	*****	*****	*****	2
.01000	.6000	.999964448	19043.589622872	
.01000	.5900	.999962550	19397.629170053	
.01000	.5800	.999960552	19745.714404256	
.01000	.5700	.999958448	20087.845253321	
.01000	.5600	.999956230	20424.021642981	
.01000	.5500	.999953890	20754.243493084	
.01000	.5400	.999951420	21078.510720848	
.01000	.5300	.999948808	21396.823237810	
.01000	.5200	.999946043	21709.180951294	
.01000	.5100	.999943115	22015.583761635	
.01000	.5000	.999940010	22316.031564656	
.01000	.4900	.999936712	22610.524249454	
.01000	.4800	.999933206	22899.061698282	
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.01000	.4300	.999911852	24252.415726944	
.01000	.4200	.999906642	24505.218823215	
.01000	.4100	.999901047	24752.065610347	
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.01000	.3800	.999881529	25456.866040895	
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K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE
*****	*****	*****	*****	3
.01000	.2000	.999520479	28559.364880588	
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.01000	.1800	.999403452	28784.799163961	
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.01000	.1600	.999239937	28986.336027496	
.01000	.1500	.999132652	29078.135928420	
.01000	.1400	.999001628	29163.951934600	
.01000	.1300	.998839314	29243.779384943	
.01000	.1200	.998634900	29317.612508771	
.01000	.1100	.998372483	29385.444044282	
.01000	.1000	.998027881	29447.264678310	
.01000	.0900	.997562885	29503.062196833	
.01000	.0800	.996914256	29552.820147617	
.01000	.0700	.995971189	29596.515637837	
.01000	.0600	.994525110	29634.115503150	
.01000	.0500	.992145183	29665.569176942	
.01000	.0400	.987822582	29690.794234100	
.01000	.0300	.978732930	29709.643719956	
.01000	.0200	.954469408	29721.821946341	
.01000	.0100	.854116873	29726.652502893	
.01000	.0091	.833350000	29726.685575660	MAX L/D - CHOKED FLOW CONDITION AT EXIT

K USED IN THESE CALCULATIONS WAS

1.40000

F USED IN THESE CALCULATIONS WAS

.02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE
*****	*****	*****	*****	4
.02000	1.0000	1.000000000	.000000098	
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.02000	.9800	.999996702	294.475007738	
.02000	.9700	.999994976	439.479440033	
.02000	.9600	.999993196	582.995137301	
.02000	.9500	.999991359	725.022083385	
.02000	.9400	.999989463	865.560262467	
.02000	.9300	.999987506	1004.609657367	
.02000	.9200	.999985485	1142.170250876	
.02000	.9100	.999983397	1278.242024619	
.02000	.9000	.999981238	1412.824959833	
.02000	.8900	.999979007	1545.919037760	
.02000	.8800	.999976699	1677.524238214	
.02000	.8700	.999974311	1807.640540649	
.02000	.8600	.999971839	1936.267923713	
.02000	.8500	.999969280	2063.406365628	
.02000	.8400	.999966629	2189.059843152	
.02000	.8300	.999963881	2313.216332787	
.02000	.8200	.999961032	2435.887810286	
.02000	.8100	.999958078	2557.070249923	
.02000	.8000	.999955011	2676.763625539	
.02000	.7900	.999951828	2794.967909586	
.02000	.7800	.999948521	2911.683073828	
.02000	.7700	.999945085	3026.909088765	
.02000	.7600	.999941512	3140.645923651	
.02000	.7500	.999937795	3252.893546858	
.02000	.7400	.999933927	3363.651924834	
.02000	.7300	.999929899	3472.921023579	
.02000	.7200	.999925702	3580.700806733	
.02000	.7100	.999921326	3686.991237330	
.02000	.7000	.999916782	3791.792275951	
.02000	.6900	.999911998	3895.103882012	
.02000	.6800	.999907022	3996.926013069	
.02000	.6700	.999901822	4097.258624744	
.02000	.6600	.999896383	4196.101670755	
.02000	.6500	.999890692	4293.455102493	
.02000	.6400	.999884733	4389.318869361	
.02000	.6300	.999878487	4483.692918127	
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K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE
.02000	.6000	.999857841	4757.876185613	5
.02000	.5900	.999850250	4846.290777388	
.02000	.5800	.999842263	4933.215343819	
.02000	.5700	.999833852	5018.649813677	
.02000	.5600	.999824987	5102.594112048	
.02000	.5500	.999815635	5185.048159936	
.02000	.5400	.999805758	5266.011874004	
.02000	.5300	.999795318	5345.485166249	
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.02000	.5100	.999772566	5499.960108005	
.02000	.5000	.999760153	5574.961554826	
.02000	.4900	.999746974	5648.472173716	
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.02000	.4700	.999718049	5791.020450657	
.02000	.4600	.999702153	5860.057051251	
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.02000	.4100	.999604469	6182.871507087	
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.02000	.3700	.999496220	6414.263388321	
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.02000	.2400	.998694734	7001.160272438	
.02000	.2300	.998572029	7035.824666596	
.02000	.2200	.998432286	7068.987701339	
.02000	.2100	.998272204	7100.648144420	

ORIGINAL PAGE IS  
OF POOR QUALITY

K USED IN THESE CALCULATIONS WAS 1.40000

F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE
*****	*****	*****	*****	6
.02000	.2000	.998087642	7130.804585902	
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.02000	.1800	.997622591	7186.598712121	
.02000	.1700	.997325615	7212.232316863	
.02000	.1600	.996973885	7236.353627794	
.02000	.1500	.996548943	7258.959567538	
.02000	.1400	.996030705	7280.045440145	
.02000	.1300	.9955389818	7299.609755124	
.02000	.1200	.994584454	7317.643984926	
.02000	.1100	.993553399	7334.142223684	
.02000	.1000	.992204246	7349.095695718	
.02000	.0900	.990392326	7362.493028838	
.02000	.0800	.987881136	7374.319147858	
.02000	.0700	.984263278	7384.553533882	
.02000	.0600	.978790429	7393.167387911	
.02000	.0500	.969972883	7400.118847133	
.02000	.0400	.954524180	7405.344732022	
.02000	.0300	.924162160	7408.746743824	
.02000	.0200	.854161594	7410.174791207	
.02000	.0183	.833400000	7410.207841247	

MAX L/D - CHOKED FLOW CONDITION AT EXIT



K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER *****	P2/P1 *****	T2/T1 *****	L/D (FEET/INCHES) *****	PAGE 7
.03000	1.0000	1.000000000	.000000011	
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.03000	.9600	.999984693	258.921133729	
.03000	.9500	.999980562	321.996379356	
.03000	.9400	.999976298	384.409577898	
.03000	.9300	.999971895	446.160712431	
.03000	.9200	.999967348	507.249765506	
.03000	.9100	.999962651	567.676719216	
.03000	.9000	.999957797	627.441554864	
.03000	.8900	.999952777	686.544253281	
.03000	.8800	.999947586	744.984794515	
.03000	.8700	.999942215	802.763158135	
.03000	.8600	.999936656	859.879322803	
.03000	.8500	.999930899	916.333266519	
.03000	.8400	.999924936	972.124966497	
.03000	.8300	.999918756	1027.254399133	
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.03000	.7900	.999891647	1241.148953341	
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.03000	.6700	.999779197	1819.233812940	
.03000	.6600	.999766969	1863.10060397	
.03000	.6500	.999754174	1906.303415669	
.03000	.6400	.999740775	1948.843828154	
.03000	.6300	.999726733	1990.721244902	
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K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE
*****	****	*****	*****	8
.03000	.6000	.999680320	2112.374952166	
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.03000	.5800	.999645302	2190.161352228	
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.03000	.5500	.999585452	2301.865459282	
.03000	.5400	.999563255	2337.773052449	
.03000	.5300	.999539792	2373.016948827	
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.03000	.5100	.999488666	2441.513275533	
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.03000	.4800	.999399688	2539.277541707	
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.03000	.4300	.999208042	2688.929189436	
.03000	.4200	.999161303	2716.864883392	
.03000	.4100	.999111112	2744.135297072	
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.03000	.2100	.996129899	3149.358604360	

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE
*****	*****	*****	*****	9
.03000	.2000	.995718451	3162.569060011	
.03000	.1900	.995241194	3175.100892217	
.03000	.1800	.994683361	3186.952282206	
.03000	.1700	.994025823	3198.121113627	
.03000	.1600	.993243443	3208.604904940	
.03000	.1500	.992302683	3218.400721855	
.03000	.1400	.991158012	3227.505062468	
.03000	.1300	.989746412	3235.913704528	
.03000	.1200	.987978725	3243.621499393	
.03000	.1100	.985725628	3250.622089726	
.03000	.1000	.982794084	3256.907516526	
.03000	.0900	.978886260	3262.467663441	
.03000	.0800	.973524531	3267.289460035	
.03000	.0700	.965907374	3271.355730059	
.03000	.0600	.954615466	3274.643537334	
.03000	.0500	.936970247	3277.121918052	
.03000	.0400	.907524848	3278.749289848	
.03000	.0300	.854236128	3279.472767715	
.03000	.0274	.833483333	3279.505779896	MAX L/D - CHOKED FLOW CONDITION AT EXIT

ORIGINAL PAGE IS  
OF POOR QUALITY

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER *****	P2/P1 *****	T2/T1 *****	L/D (FEET/INCHES) *****	PAGE 10
.04000	1.0000	1.000000000	- .000000017	
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.04000	.9800	.999986814	73.492947366	
.04000	.9700	.999979914	109.680458056	
.04000	.9600	.999972797	145.495306418	
.04000	.9500	.999965454	180.937476621	
.04000	.9400	.999957876	216.006952382	
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.04000	.9200	.999941972	285.027752494	
.04000	.9100	.999933625	318.979041497	
.04000	.9000	.999924998	352.557565249	
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.04000	.8800	.999906854	418.596239656	
.04000	.8700	.999897310	451.056349969	
.04000	.8600	.999887431	483.143614315	
.04000	.8500	.999877202	514.858010735	
.04000	.8400	.999866606	546.199516489	
.04000	.8300	.999855625	577.168108042	
.04000	.8200	.999844241	607.763761002	
.04000	.8100	.999832433	637.986450070	
.04000	.8000	.999820180	667.836149014	
.04000	.7900	.999807459	697.312830619	
.04000	.7800	.999794247	726.416466626	
.04000	.7700	.999780517	755.147027706	
.04000	.7600	.999766242	783.504483376	
.04000	.7500	.999751394	811.488801936	
.04000	.7400	.999735940	839.099950421	
.04000	.7300	.999719849	866.337894542	
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.04000	.7100	.999685604	919.694025332	
.04000	.7000	.999667373	945.812136028	
.04000	.6900	.999648345	971.556890213	
.04000	.6800	.999628473	996.928245693	
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.04000	.6600	.999585989	1046.550582294	
.04000	.6500	.999563265	1070.801469229	
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.04000	.6300	.999514534	1118.182428408	
.04000	.6200	.999488385	1141.312392687	
.04000	.6100	.999460943	1164.068603758	

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 11
*****	*****	*****	*****	
.04000	.6000	.999432120	1186.451000854	
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.04000	.5800	.999369950	1230.094094651	
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.04000	.5600	.999301018	1272.241123281	
.04000	.5500	.999263706	1292.753424975	
.04000	.5400	.999224308	1312.891476370	
.04000	.5300	.999182666	1332.655190392	
.04000	.5200	.999138606	1352.044475051	
.04000	.5100	.999091937	1371.059233053	
.04000	.5000	.999042450	1389.699361370	
.04000	.4900	.998989913	1407.964750814	
.04000	.4800	.998934070	1425.855285509	
.04000	.4700	.998874639	1443.370842353	
.04000	.4600	.998811306	1460.511290394	
.04000	.4500	.998743721	1477.276490157	
.04000	.4400	.998671496	1493.666292895	
.04000	.4300	.998594197	1509.680539737	
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.04000	.4100	.998422373	1540.581673980	
.04000	.4000	.998326688	1555.468184092	
.04000	.3900	.998223589	1569.978381246	
.04000	.3800	.998112292	1584.112039520	
.04000	.3700	.997991906	1597.868915259	
.04000	.3600	.997861414	1611.248745170	
.04000	.3500	.997719655	1624.251244177	
.04000	.3400	.997565297	1636.876102957	
.04000	.3300	.997396803	1649.122985132	
.04000	.3200	.997212398	1660.991524038	
.04000	.3100	.997010018	1672.481319008	
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.04000	.2400	.994821831	1742.261893563	
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.04000	.2200	.993790287	1758.756028711	
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K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 12
*****	****	*****	*****	
.04000	.2000	.992440495	1773.705754711	
.04000	.1900	.991603959	1780.598038728	
.04000	.1800	.990627721	1787.099699633	
.04000	.1700	.989479099	1793.208729602	
.04000	.1600	.988115351	1798.922788707	
.04000	.1500	.986479754	1804.239130075	
.04000	.1400	.984495804	1809.154503750	
.04000	.1300	.982058437	1813.665032106	
.04000	.1200	.979020422	1817.766047045	
.04000	.1100	.975170700	1821.451875820	
.04000	.1000	.970198854	1824.715558268	
.04000	.0900	.963634877	1827.548474563	
.04000	.0800	.954743265	1829.939863132	
.04000	.0700	.942329189	1831.876224732	
.04000	.0600	.924368290	1833.340675067	
.04000	.0500	.897268405	1834.312519876	
.04000	.0400	.854340472	1834.767933482	
.04000	.0365	.833600000	1834.800892708	MAX L/D - CHOKED FLOW CONDITION AT EXIT

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 13
*****	****	*****	*****	
.05000	1.0000	1.000000000	-.000000006	
.05000	.9900	.999989858	23.606927230	
.05000	.9800	.999979405	46.975151799	
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.05000	.9500	.999946043	115.647458698	
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.05000	.9200	.999909370	182.170878357	
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.05000	.9000	.999882861	225.325768806	
.05000	.8900	.999868932	246.544941678	
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.05000	.7600	.999634981	500.648401672	
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K USED IN THESE CALCULATIONS WAS

1.40000

F USED IN THESE CALCULATIONS WAS

.02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE
*****	*****	*****	*****	14
.05000	.6000	.999113572	757.882107255	
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.05000	.5600	.998909089	812.601374720	
.05000	.5500	.998850904	825.680803672	
.05000	.5400	.998789471	838.519919892	
.05000	.5300	.998724545	851.118636994	
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.05000	.5000	.998505972	887.471454568	
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.05000	.4700	.998244473	921.657058236	
.05000	.4600	.998145806	932.570102847	
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.05000	.3700	.996870523	1019.908955106	
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.05000	.3500	.996447317	1036.649602408	
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.05000	.3200	.995659483	1059.932247079	
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K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 15
*****	*****	*****	*****	
.05000	.2000	.988291011	1130.881110058	
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.05000	.1700	.983756457	1142.963489035	
.05000	.1600	.981677900	1146.473408733	
.05000	.1500	.979192916	1149.720633684	
.05000	.1400	.976190124	1152.702207506	
.05000	.1300	.972518010	1155.414648713	
.05000	.1200	.967966684	1157.853832585	
.05000	.1100	.962239471	1160.014844970	
.05000	.1000	.954907576	1161.891804876	
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.05000	.0700	.915058039	1165.740708207	
.05000	.0600	.890389738	1166.396355288	
.05000	.0500	.854474624	1166.718384262	
.05000	.0457	.833750000	1166.751275481	MAX L/D - CHOKED FLOW CONDITION AT EXIT 1

ORIGINAL PAGE IS  
OF POOR  
QUALITY

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 16
*****	*****	*****	*****	
.06000	1.0000	1.000000000	.000000003	
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.06000	.9400	.999905306	95.719688435	
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K USED IN THESE CALCULATIONS WAS

1.40000

F USED IN THESE CALCULATIONS WAS

.02000

MACH NUMBER *****	P2/P1 *****	T2/T1 *****	L/D (FEET/INCHES) *****	PAGE 17
.06000	.6000	.998725096	525.080966942	
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.06000	.4900	.997734820	622.694399581	
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.06000	.2100	.984883344	778.662972842	

K USED IN THESE CALCULATIONS WAS

1.40000

F USED IN THESE CALCULATIONS WAS

.02000

MACH NUMBER

P2/P1

T2/T1

L/D (FEET/INCHES)

PAGE 18

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.06000

.2000

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MAX L/D - CHOKED FLOW CONDITION AT EXIT

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER *****	P2/P1 *****	T2/T1 *****	L/D (FEET/INCHES) *****	PAGE 19
.07000	1.0000	1.000000000	-.000000002	
.07000	.9900	.999980142	12.003509548	
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.07000	.8000	.999450433	216.855187062	
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.07000	.7000	.998984062	306.923675982	
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.07000	.6800	.998865429	323.464976888	
.07000	.6700	.998802113	331.551325894	
.07000	.6600	.998735914	339.514747660	
.07000	.6500	.998666655	347.355194969	
.07000	.6400	.998594144	355.072618453	
.07000	.6300	.998518176	362.666966460	
.07000	.6200	.998438528	370.138184908	
.07000	.6100	.998354957	377.486217137	

K USED IN THESE CALCULATIONS WAS

1.40000

F USED IN THESE CALCULATIONS WAS

.02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE	20
*****	****	*****	*****		
.07000	.6000	.998267204	384.711003739		
.07000	.5900	.998174984	391.812482381		
.07000	.5800	.998077989	398.790587608		
.07000	.5700	.997975886	405.645250639		
.07000	.5500	.997868309	412.376399129		
.07000	.5500	.997754861	418.983956931		
.07000	.5400	.997635109	425.467843819		
.07000	.5300	.997508576	431.827975200		
.07000	.5200	.997374744	438.064261786		
.07000	.5100	.997233040	444.176609252		
.07000	.5000	.997082837	450.164917846		
.07000	.4900	.996923443	456.029081973		
.07000	.4800	.996754096	461.768989731		
.07000	.4700	.996573950	467.384522407		
.07000	.4600	.996382071	472.875553914		
.07000	.4500	.996177422	478.241950181		
.07000	.4400	.995958846	483.483568465		
.07000	.4300	.995725057	488.600256603		
.07000	.4200	.995474613	493.591852167		
.07000	.4100	.995205901	498.458181543		
.07000	.4000	.994917107	503.199058885		
.07000	.3900	.994606189	507.814284960		
.07000	.3800	.994270838	512.303645854		
.07000	.3700	.993908438	516.666911514		
.07000	.3600	.993516014	520.903834114		
.07000	.3500	.993090175	525.014146213		
.07000	.3400	.992627039	528.997558670		
.07000	.3300	.992122147	532.853758289		
.07000	.3200	.991570356	536.582405130		
.07000	.3100	.990965715	540.183129459		
.07000	.3000	.990301303	543.655528260		
.07000	.2900	.989569038	546.999161233		
.07000	.2800	.988759435	550.213546199		
.07000	.2700	.987861309	553.298153807		
.07000	.2600	.986861398	556.252401414		
.07000	.2500	.985743885	559.075645983		
.07000	.2400	.984489796	561.767175838		
.07000	.2300	.983076218	564.326201048		
.07000	.2200	.981475292	566.751842185		
.07000	.2100	.979652894	569.043117179		

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 21
*****	*****	*****	*****	
.07000	.2000	.977566893	571.198925888	
.07000	.1900	.975164833	573.218032018	
.07000	.1800	.972380804	575.099041929	
.07000	.1700	.969131179	576.840379882	
.07000	.1600	.965308730	578.440259301	
.07000	.1500	.960774412	579.896649793	
.07000	.1400	.955345727	581.207240017	
.07000	.1300	.948780010	582.369397347	
.07000	.1200	.940750101	583.380126793	
.07000	.1100	.930808412	584.236034699	
.07000	.1000	.918333103	584.933308260	
.07000	.0900	.902446486	585.467731898	
.07000	.0800	.881890077	585.834778970	
.07000	.0700	.854832336	586.029846274	
.07000	.0639	.834150000	586.062556573	MAX L/D - CHOKED FLOW CONDITION AT EXIT

ORIGINAL PAGE IS  
OF POOR QUALITY

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER *****	P2/P1 *****	T2/T1 *****	L/D (FEET/INCHES) *****	PAGE 22
.08000	1.0000	1.000000000	-.000000002	
.08000	.9900	.999974079	9.170674618	
.08000	.9800	.999947362	18.247739508	
.08000	.9700	.999919819	27.231179973	
.08000	.9600	.999891413	36.120980866	
.08000	.9500	.999862109	44.917126567	
.08000	.9400	.999831868	53.619600969	
.08000	.9300	.999800650	62.228387455	
.08000	.9200	.999768413	70.743468871	
.08000	.9100	.999735112	79.164827515	
.08000	.9000	.999700699	87.492445100	
.08000	.8900	.999665125	95.726302739	
.08000	.8800	.999628336	103.866380909	
.08000	.8700	.999590277	111.912659430	
.08000	.8600	.999550889	119.865117433	
.08000	.8500	.999510109	127.723733325	
.08000	.8400	.999467871	135.488434761	
.08000	.8300	.999424105	143.159348601	
.08000	.8200	.999378736	150.736300883	
.08000	.8100	.999331685	158.219316773	
.08000	.8000	.999282868	165.608370528	
.08000	.7900	.999232195	172.903435451	
.08000	.7800	.999179572	180.104483842	
.08000	.7700	.999124897	187.211486948	
.08000	.7600	.999068062	194.224414910	
.08000	.7500	.999008953	201.143236703	
.08000	.7400	.998947445	207.967920079	
.08000	.7300	.998883409	214.698431501	
.08000	.7200	.998816704	221.334736069	
.08000	.7100	.998747180	227.876797454	
.08000	.7000	.998674675	234.324577810	
.08000	.6900	.998599017	240.678037698	
.08000	.6800	.998520021	246.937135989	
.08000	.6700	.998437489	253.101829770	
.08000	.6600	.998351206	259.172074239	
.08000	.6500	.998260942	265.147822593	
.08000	.6400	.998166449	271.029025909	
.08000	.6300	.998067459	276.815633014	
.08000	.6200	.997963683	282.507590347	
.08000	.6100	.997854807	288.104841807	



K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 23
*****	*****	*****	*****	
.08000	.6000	.997740494	293.607328593	
.08000	.5900	.997620375	299.014989030	
.08000	.5800	.997494052	304.327758378	
.08000	.5700	.997361092	309.545568629	
.08000	.5600	.997221021	314.668348284	
.08000	.5500	.997073327	319.696022116	
.08000	.5400	.996917446	324.628510902	
.08000	.5300	.996752764	329.465731144	
.08000	.5200	.996578609	334.207594759	
.08000	.5100	.996394241	338.854008736	
.08000	.5000	.996198850	343.404874769	
.08000	.4900	.995991541	347.860088855	
.08000	.4800	.995771330	352.219540846	
.08000	.4700	.995537127	356.483113964	
.08000	.4600	.995287727	360.650684267	
.08000	.4500	.995021790	364.722120057	
.08000	.4400	.994737829	368.697281232	
.08000	.4300	.994434185	372.576018566	
.08000	.4200	.994109005	376.358172913	
.08000	.4100	.993760214	380.043574323	
.08000	.4000	.993385482	383.632041067	
.08000	.3900	.992982186	387.123378535	
.08000	.3800	.992547366	390.517378026	
.08000	.3700	.992077669	393.813815379	
.08000	.3600	.991569287	397.012449451	
.08000	.3500	.991017885	400.113020398	
.08000	.3400	.990418504	403.115247748	
.08000	.3300	.989765458	406.018828225	
.08000	.3200	.989052197	408.823433288	
.08000	.3100	.988271153	411.528706347	
.08000	.3000	.987413540	414.134259595	
.08000	.2900	.986469117	416.639670409	
.08000	.2800	.985425891	419.044477241	
.08000	.2700	.984269749	421.348174930	
.08000	.2600	.982983999	423.550209320	
.08000	.2500	.981548789	425.649971100	
.08000	.2400	.979940375	427.6446788726	
.08000	.2300	.978130180	429.539920281	
.08000	.2200	.976083592	431.328544118	
.08000	.2100	.973758392	433.011748116	

K USED IN THESE CALCULATIONS WAS

1.40000

F USED IN THESE CALCULATIONS WAS

.02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE	24
*****	*****	*****	*****		
.08000	.2000	.971102705	434.588517356		
.08000	.1900	.968052291	436.057720052		
.08000	.1800	.964526926	437.418091605		
.08000	.1700	.960425535	438.668216732		
.08000	.1600	.955619563	439.806509811		
.08000	.1500	.949943847	440.831193927		
.08000	.1400	.943183938	441.740279741		
.08000	.1300	.935058257	442.531546352		
.08000	.1200	.925192745	443.202528228		
.08000	.1100	.913084481	443.750515362		
.08000	.1000	.898049019	444.172578941		
.08000	.0900	.879143716	444.465642997		
.08000	.0800	.855055886	444.626634911		
.08000	.0731	.834400000	444.659232452		
					MAX L/D - CHOKED FLOW CONDITION AT EXIT

K USED IN THESE CALCULATIONS WAS 1.40000

F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)
*****	*****	*****	*****
.10000	1.3000	1.000000000	-.000000000
.10000	.9900	.999959557	5.839322249
.10000	.9800	.999917876	11.618520260
.10000	.9700	.999874907	17.337579477
.10000	.9600	.999830596	22.996484901
.10000	.9500	.999784887	28.595221070
.10000	.9400	.999737720	34.133772039
.10000	.9300	.999689032	39.612121364
.10000	.9200	.999638758	45.030252076
.10000	.9100	.999586828	50.388146663
.10000	.9000	.999533169	55.685787043
.10000	.8900	.999477703	60.923154541
.10000	.8800	.999420349	66.100229863
.10000	.8700	.999361019	71.216993067
.10000	.8600	.999299622	76.273423537
.10000	.8500	.999236062	81.269499949
.10000	.8400	.999170235	86.205200240
.10000	.8300	.999102033	91.080501574
.10000	.8200	.999031340	95.895380305
.10000	.8100	.998958033	100.649811938
.10000	.8000	.998881984	105.343771091
.10000	.7900	.998803052	109.977231447
.10000	.7800	.998721092	114.550165713
.10000	.7700	.998635946	119.062545569
.10000	.7600	.998547448	123.514341615
.10000	.7500	.998455420	127.905523318
.10000	.7400	.998359671	132.236058954
.10000	.7300	.998260000	136.505915543
.10000	.7200	.998156189	140.715058784
.10000	.7100	.998048007	144.863452986
.10000	.7000	.997935205	148.951060988
.10000	.6900	.997817518	152.977844084
.10000	.6800	.997694660	156.943761929
.10000	.6700	.997566324	160.848772455
.10000	.6600	.997432181	164.692831768
.10000	.6500	.997291877	168.475894038
.10000	.6400	.997145028	172.197911395
.10000	.6300	.996991224	175.858833797
.10000	.6200	.996830020	179.458608905
.10000	.6100	.996660935	182.997181938

K USED IN THESE CALCULATIONS WAS

1.40000

F USED IN THESE CALCULATIONS WAS

.02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE	26
*****	*****	*****	*****		
.10000	.6000	.996483449	186.474495524		
.10000	.5900	.996296997	189.890489536		
.10000	.5800	.996100968	193.245100910		
.10000	.5700	.995894698	196.538263460		
.10000	.5600	.995677464	199.769907669		
.10000	.5500	.995448478	202.939960465		
.10000	.5400	.995206881	206.048344978		
.10000	.5300	.994951734	209.094980278		
.10000	.5200	.994682010	212.079781089		
.10000	.5100	.994396582	215.002657475		
.10000	.5000	.994094214	217.863514507		
.10000	.4900	.993773546	220.662251890		
.10000	.4800	.993433079	223.398763557		
.10000	.4700	.993071160	226.072937234		
.10000	.4600	.992685960	228.684653954		
.10000	.4500	.992275451	231.233787527		
.10000	.4400	.991837382	233.720203960		
.10000	.4300	.991369248	236.143760818		
.10000	.4200	.990868255	238.504306521		
.10000	.4100	.990331279	240.801679569		
.10000	.4000	.989754818	243.035707681		
.10000	.3900	.989134939	245.206206857		
.10000	.3800	.988467210	247.312980320		
.10000	.3700	.987746627	249.355817361		
.10000	.3600	.986967517	251.334492043		
.10000	.3500	.986123438	253.248761767		
.10000	.3400	.985207043	255.098365673		
.10000	.3300	.984209932	256.883022861		
.10000	.3200	.983122465	258.602430397		
.10000	.3100	.981933539	260.256261099		
.10000	.3000	.980630315	261.844161048		
.10000	.2900	.979197895	263.365746821		
.10000	.2800	.977618910	264.820602381		
.10000	.2700	.975873027	266.204275613		
.10000	.2600	.973936332	267.528274457		
.10000	.2500	.971780561	268.780062593		
.10000	.2400	.969372141	269.963054662		
.10000	.2300	.966670973	271.076610979		
.10000	.2200	.963628899	272.120031747		
.10000	.2100	.960187733	273.092550777		

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 27
*****	*****	*****	*****	
.10000	.2000	.956276740	273.993328797	
.10000	.1900	.951809360	274.821446501	
.10000	.1800	.946678949	275.575897604	
.10000	.1700	.940753180	276.255582388	
.10000	.1600	.933866647	276.859302511	
.10000	.1500	.925811018	277.385758313	
.10000	.1400	.916321862	277.833550540	
.10000	.1300	.905060916	278.201189432	
.10000	.1200	.891592145	278.487115565	
.10000	.1100	.875349343	278.689738943	
.10000	.1000	.855892347	278.807505537	
.10000	.0914	.835000000	278.839833458	MAX L/D - CHOKED FLOW CONDITION AT EXIT

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OF POOR QUALITY

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 28
*****	*****	*****	*****	
.12000	1.0000	1.000000000	.000000000	
.12000	.9900	.999941866	4.029780318	
.12000	.9800	.999881957	8.017628292	
.12000	.9700	.999820201	11.963529537	
.12000	.9600	.999756522	15.867469231	
.12000	.9500	.999690837	19.729432102	
.12000	.9400	.999623063	23.549402404	
.12000	.9300	.999553111	27.327363901	
.12000	.9200	.999480885	31.063299846	
.12000	.9100	.999406288	34.757192958	
.12000	.9000	.999329213	38.409025399	
.12000	.8900	.999249551	42.018778754	
.12000	.8800	.999167184	45.586434001	
.12000	.8700	.999081989	49.111971488	
.12000	.8600	.998993835	52.595370903	
.12000	.8500	.998902585	56.036611246	
.12000	.8400	.998808091	59.435670793	
.12000	.8300	.998710200	62.792527073	
.12000	.8200	.998608745	66.107156821	
.12000	.8100	.998503553	69.379535951	
.12000	.8000	.998394438	72.609639512	
.12000	.7900	.998281205	75.797441646	
.12000	.7800	.998163642	78.942915548	
.12000	.7700	.998041528	82.046033415	
.12000	.7600	.997914625	85.106766402	
.12000	.7500	.997782680	88.125084564	
.12000	.7400	.997645424	91.100956802	
.12000	.7300	.997502569	94.034350808	
.12000	.7200	.997353808	96.925232996	
.12000	.7100	.997198810	99.773568437	
.12000	.7000	.997037225	102.579320789	
.12000	.6900	.996868675	105.342452221	
.12000	.6800	.996692756	108.062923327	
.12000	.6700	.996509033	110.740693045	
.12000	.6600	.996317040	113.375718561	
.12000	.6500	.996116276	115.967955209	
.12000	.6400	.995906201	118.517356367	
.12000	.6300	.995686233	121.023873339	
.12000	.6200	.995455743	123.487455238	
.12000	.6100	.995214053	125.908048851	

K USED IN THESE CALCULATIONS WAS

1.40000

F USED IN THESE CALCULATIONS WAS

.02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE	29
*****	*****	*****	*****		
.12000	.6000	.994960430	128.285598500		
.12000	.5900	.994694079	130.620045887		
.12000	.5800	.994414140	132.911329935		
.12000	.5700	.994119677	135.159386611		
.12000	.5600	.993809674	137.364148735		
.12000	.5500	.993483026	139.525545776		
.12000	.5400	.993138527	141.643503633		
.12000	.5300	.992774861	143.717944394		
.12000	.5200	.992390590	145.748786078		
.12000	.5100	.991984138	147.735942356		
.12000	.5000	.991553779	149.679322245		
.12000	.4900	.991097616	151.578829779		
.12000	.4800	.990613560	153.434363652		
.12000	.4700	.990099310	155.245816829		
.12000	.4600	.989552326	157.013076116		
.12000	.4500	.988969795	158.736021703		
.12000	.4400	.988348601	160.414526657		
.12000	.4300	.987685279	162.048456371		
.12000	.4200	.986975974	163.637667961		
.12000	.4100	.986216386	165.182009608		
.12000	.4000	.985401703	166.681319835		
.12000	.3900	.984526533	168.135426718		
.12000	.3800	.983584816	169.544147015		
.12000	.3700	.982569725	170.907285223		
.12000	.3600	.981473548	172.224632527		
.12000	.3500	.980287548	173.495965656		
.12000	.3400	.979001797	174.721045632		
.12000	.3300	.977604985	175.899616384		
.12000	.3200	.976084178	177.031403244		
.12000	.3100	.974424545	178.116111286		
.12000	.3000	.972609015	179.153423524		
.12000	.2900	.970617869	180.142998941		
.12000	.2800	.968428247	181.084470350		
.12000	.2700	.966013544	181.977442088		
.12000	.2600	.963342666	182.821487544		
.12000	.2500	.960379123	183.616146533		
.12000	.2400	.957079903	184.360922553		
.12000	.2300	.953394073	185.055279979		
.12000	.2200	.949261034	185.698641275		
.12000	.2100	.944608333	186.290384361		

K USED IN THESE CALCULATIONS WAS 1.40000

F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 30
*****	*****	*****	*****	
.12000	.2000	.939348902	186.829840346	
.12000	.1900	.933377568	187.316291925	
.12000	.1800	.926566607	187.748972873	
.12000	.1700	.918760075	188.127069288	
.12000	.1600	.909766544	188.449723453	
.12000	.1500	.899349761	188.716041603	
.12000	.1400	.887216647	188.925107301	
.12000	.1300	.873001846	189.076002782	
.12000	.1200	.856247905	189.167841354	
.12000	.1100	.836379957	189.199814782	
.12000	.1097	.835733333	189.199841645	MAX L/D - CHOKED FLOW CONDITION AT EXIT



K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 31
*****	*****	*****	*****	
.14000	1.0000	1.000000000	-.000000000	
.14000	.9900	.999921040	2.938768154	
.14000	.9800	.999839676	5.846575413	
.14000	.9700	.999755811	8.723407593	
.14000	.9600	.999669340	11.569250081	
.14000	.9500	.999580156	14.384087824	
.14000	.9400	.999488144	17.167905307	
.14000	.9300	.999393183	19.920686539	
.14000	.9200	.999295147	22.642415028	
.14000	.9100	.999193901	25.333073763	
.14000	.9000	.999089304	27.992645193	
.14000	.8900	.998981209	30.621111202	
.14000	.8800	.998869456	33.218453087	
.14000	.8700	.998753880	35.784651529	
.14000	.8600	.998634305	38.319686572	
.14000	.8500	.998510545	40.823537590	
.14000	.8400	.998382403	43.296183257	
.14000	.8300	.998249671	45.737601519	
.14000	.8200	.998112128	48.147769559	
.14000	.8100	.997969539	50.526663760	
.14000	.8000	.997821656	52.874259673	
.14000	.7900	.997668213	55.190531971	
.14000	.7800	.997508931	57.475454413	
.14000	.7700	.997343510	59.728999797	
.14000	.7600	.997171633	61.951139914	
.14000	.7500	.996992960	64.141845499	
.14000	.7400	.996807130	66.301086179	
.14000	.7300	.996613757	68.428830416	
.14000	.7200	.996412431	70.525045449	
.14000	.7100	.996202710	72.589697230	
.14000	.7000	.995984125	74.622750358	
.14000	.6900	.995756171	76.624168005	
.14000	.6800	.995518308	78.593911848	
.14000	.6700	.995269957	80.531941977	
.14000	.6600	.995010496	82.438216819	
.14000	.6500	.994739256	84.312693038	
.14000	.6400	.994455518	86.155325443	
.14000	.6300	.994158507	87.966066879	
.14000	.6200	.993847388	89.744868116	
.14000	.6100	.993521260	91.491677730	

ORIGINAL PAGE IS OF POOR QUALITY

K USED IN THESE CALCULATIONS WAS

1.40000

F USED IN THESE CALCULATIONS WAS

.02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE
*****	*****	*****	*****	32
.14000	.6000	.993179148	93.206441970	
.14000	.5900	.992819998	94.889104627	
.14000	.5800	.992442668	96.539606878	
.14000	.5700	.992045922	98.157887134	
.14000	.5600	.991628414	99.743880864	
.14000	.5500	.991188682	101.297520417	
.14000	.5400	.990725136	102.818734817	
.14000	.5300	.990236040	104.307449558	
.14000	.5200	.989719500	105.763586371	
.14000	.5100	.989173444	107.187062979	
.14000	.5000	.988595603	108.577792826	
.14000	.4900	.987983488	109.935684797	
.14000	.4800	.987334365	111.260642902	
.14000	.4700	.986645225	112.552565942	
.14000	.4600	.985912751	113.811347144	
.14000	.4500	.985133278	115.036873773	
.14000	.4400	.984302751	116.229026703	
.14000	.4300	.983416675	117.387679954	
.14000	.4200	.982470057	118.512700203	
.14000	.4100	.981457339	119.603946235	
.14000	.4000	.980372318	120.661268361	
.14000	.3900	.979208062	121.684507789	
.14000	.3800	.977956800	122.673495934	
.14000	.3700	.976609806	123.623053682	
.14000	.3600	.975157252	124.547990588	
.14000	.3500	.973588042	125.433104017	
.14000	.3400	.971889618	126.283178217	
.14000	.3300	.970047723	127.097983325	
.14000	.3200	.968046131	127.877274305	
.14000	.3100	.965886315	128.620789826	
.14000	.3000	.963487059	129.328251070	
.14000	.2900	.960883991	129.999360489	
.14000	.2800	.958029020	130.633800524	
.14000	.2700	.954889658	131.231232306	
.14000	.2600	.951428206	131.791294367	
.14000	.2500	.947600752	132.313601475	
.14000	.2400	.943355967	132.797743239	
.14000	.2300	.938633618	133.243283828	
.14000	.2200	.933362752	133.649760854	
.14000	.2100	.927459462	134.016685673	

K USED IN THESE CALCULATIONS WAS 1.40000

F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER

P2/P1

T2/T1

L/D (FEET/INCHES)

PAGE 33

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.14000	.2000	.920824127	134.343544104
.14000	.1900	.913337998	134.629798301
.14000	.1800	.904858968	134.874890165
.14000	.1700	.895216328	135.078246842
.14000	.1600	.884204248	135.239289082
.14000	.1500	.871573705	135.357443385
.14000	.1400	.857022490	135.432159131
.14000	.1300	.840182915	135.462932140
.14000	.1281	.836600000	135.463774916

MAX L/D - CHOKED FLOW CONDITION AT EXIT

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OF POOR QUALITY

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE	34
*****	*****	*****	*****		
.16000	1.0000	1.000000000	.000000000		
.16000	.9900	.999897118	2.230745889		
.16000	.9800	.999791115	4.437654128		
.16000	.9700	.999681863	6.620710759		
.16000	.9600	.999569230	8.779901406		
.16000	.9500	.999453074	10.915211265		
.16000	.9400	.999333247	13.026625087		
.16000	.9300	.999209595	15.114127152		
.16000	.9200	.999081952	17.177701253		
.16000	.9100	.998950147	19.217330713		
.16000	.9000	.998813997	21.232998275		
.16000	.8900	.998673309	23.224686174		
.16000	.8800	.998527881	25.192376054		
.16000	.8700	.998377499	27.138049009		
.16000	.8600	.998221935	29.055685451		
.16000	.8500	.998060950	30.951265188		
.16000	.8400	.997894291	32.822767343		
.16000	.8300	.997721689	34.670170335		
.16000	.8200	.997542859	36.493451850		
.16000	.8100	.997357500	38.292588803		
.16000	.8000	.997165291	40.067557307		
.16000	.7900	.996965893	41.818332636		
.16000	.7800	.996758946	43.544889182		
.16000	.7700	.996544064	45.247200419		
.16000	.7600	.996320840	46.925238855		
.16000	.7500	.996088839	48.578975990		
.16000	.7400	.995847597	50.208382262		
.16000	.7300	.995596621	51.813427000		
.16000	.7200	.995335382	53.394078365		
.16000	.7100	.995063318	54.950303296		
.16000	.7000	.994779827	56.482067444		
.16000	.6900	.994484263	57.989335109		
.16000	.6800	.994175936	59.472069166		
.16000	.6700	.993854107	60.930230999		
.16000	.6600	.993517982	62.363780414		
.16000	.6500	.993166707	63.772675558		
.16000	.6400	.992799368	65.156872830		
.16000	.6300	.992414976	66.516326786		
.16000	.6200	.992012470	67.850990033		
.16000	.6100	.991590704	69.160813129		

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 35
*****	****	****	*****	
.16000	.6000	.991148441	70.445744460	
.16000	.5900	.990684344	71.705730117	
.16000	.5800	.990196965	72.940713768	
.16000	.5700	.989684738	74.150636515	
.16000	.5600	.989145963	75.335436742	
.16000	.5500	.988578794	76.495049952	
.16000	.5400	.987981223	77.629408600	
.16000	.5300	.987351064	78.738441903	
.16000	.5200	.986685934	79.822075642	
.16000	.5100	.985983229	80.880231952	
.16000	.5000	.985240104	81.912829091	
.16000	.4900	.984453441	82.919781199	
.16000	.4800	.983619823	83.900998035	
.16000	.4700	.982735493	84.856384695	
.16000	.4600	.981796319	85.785841313	
.16000	.4500	.980797744	86.689262739	
.16000	.4400	.979734740	87.566538189	
.16000	.4300	.978601740	88.417550880	
.16000	.4200	.977392580	89.242177633	
.16000	.4100	.976100412	90.040288449	
.16000	.4000	.974717618	90.811746056	
.16000	.3900	.973235705	91.556405433	
.16000	.3800	.971645186	92.274113294	
.16000	.3700	.969935437	92.964707552	
.16000	.3600	.968094537	93.628016743	
.16000	.3500	.966109079	94.263859431	
.16000	.3400	.963963948	94.872043582	
.16000	.3300	.961642058	95.452365918	
.16000	.3200	.959124053	96.004611254	
.16000	.3100	.956387942	96.528551838	
.16000	.3000	.953408677	97.023946685	
.16000	.2900	.950157649	97.490540953	
.16000	.2800	.946602089	97.928065363	
.16000	.2700	.942704355	98.336235710	
.16000	.2600	.938421084	98.714752502	
.16000	.2500	.933702166	99.063300802	
.16000	.2400	.928489528	99.381550332	
.16000	.2300	.922715662	99.669155965	
.16000	.2200	.916301849	99.925758717	
.16000	.2100	.909156028	100.150987435	

ORIGINAL PAGE IS  
OF POOR QUALITY

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 36
*****	*****	*****	*****	
.16000	.2000	.901170209	100.344461378	
.16000	.1900	.892217360	100.505793981	
.16000	.1800	.882147641	100.634598150	
.16000	.1700	.870783861	100.730493494	
.16000	.1600	.857916020	100.793116022	
.16000	.1500	.843294764	100.822130888	
.16000	.1464	.837600000	100.824291757	MAX L/D - CHOKED FLOW CONDITION AT EXIT

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER *****	P2/P1 *****	T2/T1 *****	L/D (FEET/INCHES) *****	PAGE 37
.18000	1.0000	1.000000000	-.000000000	
.18000	.9900	.999870147	1.749416133	
.18000	.9800	.999736368	3.471880660	
.18000	.9700	.999598505	5.179379873	
.18000	.9600	.999456392	6.867899662	
.18000	.9500	.999309852	8.537425499	
.18000	.9400	.999158699	10.187942426	
.18000	.9300	.999002740	11.819435034	
.18000	.9200	.998841770	13.431887445	
.18000	.9100	.998675572	15.025283294	
.18000	.9000	.998503919	16.599605713	
.18000	.8900	.998326572	18.154837304	
.18000	.8800	.998143276	19.690960121	
.18000	.8700	.997953764	21.207955646	
.18000	.8600	.997757754	22.705804767	
.18000	.8500	.997554947	24.184487750	
.18000	.8400	.997345027	25.643984213	
.18000	.8300	.997127659	27.084273102	
.18000	.8200	.996902489	28.505332654	
.18000	.8100	.996669142	29.907140374	
.18000	.8000	.996427220	31.289672997	
.18000	.7900	.996176299	32.652906456	
.18000	.7800	.995915933	33.996815843	
.18000	.7700	.995645643	35.321375376	
.18000	.7600	.995364923	36.626558352	
.18000	.7500	.995073233	37.912337110	
.18000	.7400	.994759999	39.178682982	
.18000	.7300	.994454609	40.425566245	
.18000	.7200	.994126409	41.652956076	
.18000	.7100	.993784701	42.860820491	
.18000	.7000	.993428742	44.049126293	
.18000	.6900	.993057735	45.217839012	
.18000	.6800	.992670826	46.366922839	
.18000	.6700	.992267104	47.496340563	
.18000	.6600	.991845588	48.606053494	
.18000	.6500	.991405230	49.696021392	
.18000	.6400	.990944899	50.766202386	
.18000	.6300	.990463384	51.816552886	
.18000	.6200	.989959379	52.847027494	
.18000	.6100	.989431476	53.857578911	

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OF POOR QUALITY

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE	38
*****	****	*****	*****		
.18000	.5000	.988878160	54.848157828		
.18000	.5900	.988297792	55.818712825		
.18000	.5800	.987688602	56.769190249		
.18000	.5700	.987048674	57.699534094		
.18000	.5500	.986375935	58.609685871		
.18000	.5500	.985668132	59.499584468		
.18000	.5400	.984922823	60.369166002		
.18000	.5300	.984137349	61.218363661		
.18000	.5200	.983308818	62.047107538		
.18000	.5100	.982434075	62.855324453		
.18000	.5000	.981509677	63.642937761		
.18000	.4900	.980531858	64.409867154		
.18000	.4800	.979496498	65.156028447		
.18000	.4700	.978399078	65.881333348		
.18000	.4600	.977234635	66.585689221		
.18000	.4500	.975997711	67.268998832		
.18000	.4400	.974682293	67.931160076		
.18000	.4300	.973281745	68.572065697		
.18000	.4200	.971788734	69.191602986		
.18000	.4100	.970195138	69.789653472		
.18000	.4000	.968491946	70.366092588		
.18000	.3900	.966669145	70.920789338		
.18000	.3800	.964715585	71.453605939		
.18000	.3700	.962618825	71.964397461		
.18000	.3600	.960364957	72.453011463		
.18000	.3500	.957938400	72.919287617		
.18000	.3400	.955321662	73.363057355		
.18000	.3300	.952495064	73.784143509		
.18000	.3200	.949436414	74.182359993		
.18000	.3100	.946120637	74.557511510		
.18000	.3000	.942519327	74.909393328		
.18000	.2900	.938600235	75.237791128		
.18000	.2800	.934326662	75.542480968		
.18000	.2700	.929656742	75.823229396		
.18000	.2600	.924542602	76.079793761		
.18000	.2500	.918929374	76.311922785		
.18000	.2400	.912754013	76.519357472		
.18000	.2300	.905943917	76.701832443		
.18000	.2200	.898415286	76.859077825		
.18000	.2100	.890071178	76.990821825		



K USED IN THESE CALCULATIONS WAS 1.40000

F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 39
*****	*****	*****	*****	
.18000	.2000	.880799222	77.096794164	
.18000	.1900	.870468907	77.176730581	
.18000	.1800	.858928401	77.230378624	
.18000	.1700	.846000811	77.257505032	
.18000	.1648	.838733333	77.261060290	MAX L/D - CHOKED FLOW CONDITION AT EXIT

K USED IN THESE CALCULATIONS WAS 1.4000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE	40
*****	*****	*****	*****		
.20000	1.0000	1.000000000	- .000000000		
.20000	.9900	.999840176	1.398351486		
.20000	.9800	.999675542	2.781248696		
.20000	.9700	.999505902	4.148678196		
.20000	.9600	.999331059	5.500626167		
.20000	.9500	.999150783	6.837078385		
.20000	.9400	.998964864	8.158020211		
.20000	.9300	.998773059	9.463436571		
.20000	.9200	.998575120	10.753311941		
.20000	.9100	.998370784	12.027630329		
.20000	.9000	.998159773	13.286375257		
.20000	.8900	.997941797	14.529529739		
.20000	.8800	.997716546	15.757076265		
.20000	.8700	.997483697	16.968996774		
.20000	.8600	.997242905	18.165272639		
.20000	.8500	.996993809	19.345884635		
.20000	.8400	.996736024	20.510812922		
.20000	.8300	.996469145	21.660037012		
.20000	.8200	.996192743	22.793535748		
.20000	.8100	.995906362	23.911287271		
.20000	.8000	.995609521	25.013268992		
.20000	.7900	.995301708	26.099457558		
.20000	.7800	.994982381	27.169828820		
.20000	.7700	.994650963	28.224357800		
.20000	.7600	.994306841	29.263018650		
.20000	.7500	.993949364	30.285784613		
.20000	.7400	.993577839	31.292627986		
.20000	.7300	.993191527	32.283520071		
.20000	.7200	.992789641	33.258431134		
.20000	.7100	.992371341	34.217330354		
.20000	.7000	.991935731	35.160185771		
.20000	.6900	.991481852	36.086964236		
.20000	.6800	.991008682	36.997631350		
.20000	.6700	.990515122	37.892151405		
.20000	.6600	.990000000	38.770487323		
.20000	.6500	.989462056	39.632600586		
.20000	.6400	.988899940	40.478451165		
.20000	.6300	.988312199	41.307997447		
.20000	.6200	.987697276	42.121196155		
.20000	.6100	.987053483	42.918002263		

K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER *****	P2/P1 *****	T2/T1 *****	L/D (FEET/INCHES) *****	PAGE 41
.20000	.6000	.986379031	43.698368910	
.20000	.5900	.985671952	44.462247302	
.20000	.5800	.984930145	45.209586619	
.20000	.5700	.984151336	45.940333904	
.20000	.5600	.983333063	46.654433958	
.20000	.5500	.982472660	47.351829217	
.20000	.5400	.981567236	48.032459637	
.20000	.5300	.980613652	48.696262554	
.20000	.5200	.979608497	49.343172557	
.20000	.5100	.978548057	49.973121333	
.20000	.5000	.977428286	50.586037523	
.20000	.4900	.976244770	51.181846559	
.20000	.4800	.974992683	51.760470497	
.20000	.4700	.973666747	52.321827838	
.20000	.4600	.972261180	52.865833350	
.20000	.4500	.970769632	53.392397875	
.20000	.4400	.969185131	53.901428128	
.20000	.4300	.967500000	54.392826498	
.20000	.4200	.965705776	54.866490832	
.20000	.4100	.963793115	55.322314225	
.20000	.4000	.961751685	55.760184802	
.20000	.3900	.959570038	56.179985502	
.20000	.3800	.957235471	56.581593861	
.20000	.3700	.954733864	56.964881813	
.20000	.3600	.952049492	57.329715486	
.20000	.3500	.949164811	57.675955036	
.20000	.3400	.946060213	58.003454494	
.20000	.3300	.942713741	58.312061658	
.20000	.3200	.939100762	58.601618030	
.20000	.3100	.935193586	58.871958828	
.20000	.3000	.930961028	59.122913077	
.20000	.2900	.926367897	59.354303815	
.20000	.2800	.921374408	59.565948439	
.20000	.2700	.915935492	59.757659230	
.20000	.2600	.910000000	59.929244103	
.20000	.2500	.903509772	60.080507629	
.20000	.2400	.896398559	60.211252406	
.20000	.2300	.888590767	60.321280836	
.20000	.2200	.880000000	60.410397421	
.20000	.2100	.870527366	60.478411667	

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K USED IN THESE CALCULATIONS WAS 1.40000 F USED IN THESE CALCULATIONS WAS .02000

MACH NUMBER	P2/P1	T2/T1	L/D (FEET/INCHES)	PAGE 42
*****	*****	*****	*****	
.20000	.2000	.860059523	60.525141717	
.20000	.1900	.848466422	60.550418849	
.20000	.1833	.840000000	60.555277008	MAX L/D - CHOKED FLOW CONDITION AT EXIT

## CONCLUDING REMARKS

The tabulations presented in this paper are applicable for the cases of compressible isothermal flow with friction and compressible adiabatic flow with friction. The tabulations are applicable for air, nitrogen, oxygen, and hydrogen.

The tabulations can be utilized in determining pressure drops in long or short runs of pipe. In conjunction with the weight flow equations the tabulations can be utilized in determining the pump up time of storage vessels with long and short runs of pipe.

The tabulations presented cover a wider range of Mach numbers for choked, adiabatic flow than available from commonly used engineering literatures. Additional information presented, but which is not available from this literature is (a) choked, adiabatic flow over a wide range of Mach numbers and (b) choked and unchoked isothermal flow for a wide range of Mach numbers.

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1. The Dynamics and Thermodynamics of Compressible Fluid Flow. Volume 1, by Ascher H. Shapiro; The Ronald Press Company; New York, 1953.
2. Compressed Gas Handbook, NASA SP-3045; edited by John S. Kunkle, Samuel D. Wilson and Richard A. Cota; Office of Technology Utilization; National Aeronautics and Space Administration, Washington, D.C. 1969.