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# TWO-PHASE CHOKED FLOW OF SUBCOOLED OXYGEN AND NITROGEN

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# TWO-PHASE CHOKED FLOW OF SUBCOOLED OXYGEN AND NITROGEN by Robert C. Hendricks, Robert J. Simoneau, and Richard F. Barrows Lewis Research Center

# SUMMARY

Liquid oxygen and liquid nitrogen data for two-phase critical flow through nozzles have been acquired with precision control. Test results from two converging-diverging nozzles and two separate test facilities are in excellent agreement. The critical flow rate and critical flow pressure ratio data conclusively demonstrate that the principle of corresponding states can be applied to two-phase choked flow through nozzles. Normalizing parameters have been developed to correlate these data, and current theories can provide an adequate means for extrapolating to other fluids.

## INTRODUCTION

There is a need for good flow rate information to be incorporated in the design of storage, transfer, and handling equipment used with liquid oxygen. Among the problems are safety and two-phase choked flow. The problems (and information presently available) related to the safe handling of high-pressure oxygen are discussed in the state-of-the-art reports on oxygen technology published by NASA (refs. 1 and 2).

The general field of two-phase choked flow has been well surveyed by Hsu (ref. 3), Henry, Grolmes, and Fauske (ref. 4), and Smith (ref. 5). To the knowledge of the authors, no experiment has ever been reported on two-phase choked flow of liquid oxygen. The approach at Lewis Research Center has been to concentrate on liquid nitrogen with some exploration of other fluids. The choked flow of liquid nitrogen in convergingdiverging nozzles has been extensively mapped (refs. 6 and unpublished data by R. J. Simoneau of Lewis). Simoneau also evaluates existing theories for two-phase choked flow in the subcooled region. In addition to the nozzle, other flow geometries have been examined (refs. 7 to 9). Finally, the relation between various fluids was explored (refs. 10 and 11). Hendricks and Simoneau (ref. 10), using nitrogen and methane data, demonstrated that two-phase choked flow rates could be normalized in reduced coordinates by the parameter

$$G^* = \sqrt{\frac{\rho_c P_c}{Z_c}}$$
(1)

(Symbols are defined in the following section.)

The rationale for this normalization (ref. 10) is based on the one-dimensional, adiabatic, steady-state, energy equation

$$H_0 - H = \frac{u^2}{2}$$

In terms of the mass flow rate,

$$G^2 = (\rho u)^2 = 2\rho^2 (H_0 - H)$$

It has been found (ref. 12) that enthalpy can be successfully normalized by  $RT_c$ . Thus, the normalized mass flow rate becomes

$$\frac{G^2}{(G^+)^2} = \frac{2\rho^2(H_0 - H)}{\rho_c^2(RT_c)}$$

Introducing the critical compressibility factor<sup>1</sup>

$$Z_{c} = \frac{P_{c}}{\rho_{c}RT_{c}}$$

yields

<sup>&</sup>lt;sup>1</sup>Other normalization parameters can be developed; e.g., one could apply the Kamerlingh-Onnes formulation of the principle of corresponding states  $(P_r Z_c / \rho_r T_r = P_r / \rho'_r T_r)$  rather than the van der Waals formulation (ref. 13), where  $\rho'_r$  is the ideal reduced density. Secondly, one could argue that normalizing the momentum equation directly gives  $G^* = \sqrt{\rho_c P_c}$ . The difference is  $Z_c$ ; since  $Z_c$  is 0.294 for oxygen and 0.292 for nitrogen, the data reported herein cannot resolve questions regarding which is the proper parameter or the proper formulation.

$$\frac{\mathrm{G}^2}{(\mathrm{G}^*)^2} = \frac{2\rho^2(\mathrm{H_0 - H})}{\left(\frac{\rho_{\mathrm{c}}\mathrm{P}_{\mathrm{c}}}{\mathrm{Z}_{\mathrm{c}}}\right)}$$

It is shown in reference 10 that if the flow rates, normalized by equation (1), were plotted in the reduced coordinates

$$\mathbf{P_r} = \frac{\mathbf{P_0}}{\mathbf{P_c}} \tag{2}$$

$$T_{r} = \frac{T_{0}}{T_{c}}$$
(3)

the nitrogen and methane flow rate data would reduce to a single curve. The same was true for the choked flow pressure ratio data  $P_t/P_0$ . This result implies that the extensive work done with nitrogen could be extrapolated to oxygen.

The present report gives the results of a two-phase choked flow experiment with subcooled liquid oxygen and nitrogen in converging-diverging nozzles. The experiment was undertaken to demonstrate that the corresponding-states normalization, equation (1), is applicable to oxygen and to provide actual oxygen data to guide the designer. The work was performed at the NASA Lewis Research Center Plum Brook Station. It covered a range of inlet flow parameters from below to above the thermodynamic critical conditions for both oxygen and nitrogen. A special feature of this test facility and this experiment is that it was possible to obtain a high level of control on the flow parameters. Thus, the comparisons between oxygen and nitrogen in reduced coordinates can be made with considerable precision.

#### SYMBOLS

A area, 
$$cm^2$$

- d diameter, cm
- G mass flow rate,  $g/(cm^2)(sec)$

G\* mass flow rate normalizing parameter, 
$$\sqrt{\frac{\rho_c P_c}{Z_c}}$$
, g/(cm<sup>2</sup>)(sec)

Н	enthalpy, J/g
l	length, cm
Р	pressure, N/cm <sup>2</sup>
R	gas constant, $J/(g)(K)$
r	radius, cm
S	entropy, $J/(g)(K)$
Т	temperature, K
u	velocity, cm/sec
x	axial distance, cm
Z	compressibility factor, $Z = P/\rho RT$
ρ	density, $g/cm^3$
$ ho_{\mathbf{r}}^{*}$	ideal reduced density

Subscripts:

с	thermodynamic critical conditions
max	maximum or choked flow conditions
r	reduced parameters $(P/P_c, etc.)$
sat	saturation conditions
t	throat conditions
0	stagnation conditions
1,,9	pressure tap stations (tables I and II)

# EXPERIMENTAL APPARATUS

# **Test Facility**

Figure 1 is a schematic of the system devised for this experiment. All parts and components used were initially screened for material compatibility with the more demanding safety requirements for liquid oxygen, high-pressure gaseous oxygen, and cryogenic temperature operation. All parts, except the test sections, were cleaned for liquid oxygen service by using the standard Plum Brook procedure RDL-003 (ref. 14) and assembled under clean-room and/or continuous inert gaseous purge conditions to eliminate contamination. The test sections (nozzles) were treated separately because

the authors did not wish to change the surface characteristics of these nozzles by using the nitric acid cleaning step. Also the elliptic nozzle contained some welds that were not the full-penetration welds that are standard for oxygen service. Since the test sections could not be cleaned to the normal stringent standards, a blast shield was placed around the test section to protect other components. This step and the normal oxygen operating procedure of running remotely with no personnel within 300 meters were considered adequate safety precautions for this test. All nonstandard components, except those connecting the 15.1-m<sup>3</sup>, 35-N/cm<sup>2</sup> (4000-gal, 50-psig) supply dewar to the high-pressure-run tank, were pressure tested to 1.5 times the maximum anticipated operating pressure of 1040 N/cm<sup>2</sup> (1500 psig).

Approximately 10.2 cm (4 in.) of Foamglas insulation covered the high-pressurerun tank and test nozzle section; and 5.1 cm (2 in.) of the same material covered the flow line components. This insulation minimized heat leakage into the flowing fluid during test runs. The axial dip tube, reaching nearly to the bottom of the high-pressurerun tank, was used to bubble warm gas up through the fluid in the tank when a controlled increase in temperature was required. An antiswirl baffle at the exit port in the bottom of the tank prevented entrainment of warming or pressurizing gas during flow test runs.

The tank pressurization and vent system control values were interlocked and slaved to a tank pressure sensor. Ten-turn trim-potentiometer-type remote controls permitted vernier positioning of these pneumatically (dry nitrogen) operated values in selecting and holding the tank pressure to within 0.3 N/cm<sup>2</sup> of the chosen level.

Each of the 0.76-cm (0.3-in.) throat diameter, venturi-type flowmeters in the 1.91-cm flow line was located approximately 40 inlet diameters downstream from the nearest flow path disturbance. A cylindrical, perforated, baffle-type mixing chamber (fig. 2) fitted with a platinum resistor temperature probe was mounted in-line between the flowmeters.

The hydraulically operated inlet flow control valve was slaved to the test nozzle inlet pressure. A ramp-change-type controller allowed fine adjustment of test nozzle inlet flow rate. None of the hydraulic components were exposed to oxygen; however, since they were in the vicinity of oxygen flow lines, the hydraulic operators were placed behind the blast shield mentioned previously.

The backpressure control valve was varied as required to verify choked flow conditions at the test nozzle throat during flow tests.

These built-in provisions for accurately controlling temperature and pressure permitted rather simple test procedures: The tank was loaded with liquid oxygen and then pressurized to the approximate operating pressure. Gaseous oxygen was bubbled through the liquid oxygen to preheat it to the desired temperature while permitting a small flow through the backpressure valve. The backpressure valve was then opened. The system pressure was adjusted to maintain the desired operating conditions, and a

data point was taken under stabilized conditions. The system pressure was then decreased (or increased) and a second data point taken, etc. It was also possible to maintain or adjust the desired temperature by bubbling ambient gas through the liquid oxygen at any fixed pressure while the gas was flowing. This made obtaining data points along selected isotherms quite precise. It was during this procedure that the baffle plate at the bottom of the tank prevented the gas from entraining directly into the flow stream.

# **Test Sections**

The test sections for this experiment were two axisymmetric converging-diverging nozzles. They are shown in cross section in figures 3 and 4. The pertinent dimensions are given in table I and II. Both test sections were preceded by a plenum chamber that took the directionality out of the flow in a manner similar to that shown in figure 2. The stagnation temperature was measured in this chamber.

The test section illustrated in figure 3 had a truncated cone of nominally  $7^{0}$  halfangle convergence and a cone of nominally  $3\frac{1}{2}^{0}$  half-angle divergence. The throat region had a constant-area section 3.2 diameters in length. The transition from the converging cone to the constant-area throat section was smoothed with a radius of curvature of approximately 10 times the throat radius. The transition from the constant-area throat section to the diverging cone was a sharp corner. This sharp corner was designated the throat. The test section was heavily instrumented with pressure taps near the throat. The interior surface had a 16-rms finish, and care was taken to deburr the pressure taps. Only nine pressure taps could be connected in this experiment. The pressure taps used are noted in table I. This test section was also used in unpublished experiments by R. J. Simoneau of Lewis.

The test section illustrated in figure 4 was a conventional venturi flowmeter and was designed according to the ASME long-radius flow nozzle guidelines (ref. 15). Pressure taps were subsequently installed as illustrated, and the test section was used in the experiments of references 6, 10, and 11. The converging section had a 2:1 elliptical curvature that transitioned smoothly into a constant-area section 2.1 diameters in length. The transition from the constant-area throat section to the 4.0<sup>o</sup> half-angle divergence cone was a sharp corner. This sharp corner was designated the throat. Table II gives two values for overall length. The smaller value, 6.80 cm, is the distance from the beginning of the elliptical converging section to the end of the 4.0<sup>o</sup> diverging section. The larger number is the distance from the inlet plenum to the beginning of the downstream straight section. The smaller dimension is probably more relevant, since this is really the nozzle shape under consideration. This nozzle was not as heavily instrumented in the throat region as indicated in table II. The convergence rate of the elliptical section is table II.

tical nozzle was substantially greater. Taking the beginning of the ellipse as a reference, the area ratio was 14.3 and the nozzle converged to the beginning of the constantarea throat region in 0.751 cm. For the conical nozzle, the convergence from an area ratio of 14.3 to the beginning of the throat region required a distance of 4.14 cm.

# INSTRUMENTATION AND DATA ACQUISITION

Strain-gage pressure transducers were used to measure tank pressure, flow venturi differential pressure, test nozzle pressure, and barometric pressure. Normal accuracy range for this class of strain-gage pressure transducers is  $\pm 0.5$  percent error. Before each days run the system was statically pressurized to the operating pressure, and all transducers were zero adjusted to eliminate deviations from the mean reading. This increased the precision between transducers to within an error of  $\pm 0.25$  percent.

Platinum resistance sensors were used to measure tank, flow venturi inlet, and test nozzle plenum chamber temperatures. The four tank sensors were also used to indicate liquid level. The accuracy of these sensors was within  $\pm 0.1$  percent error, and total system accuracy was within an error of  $\pm 0.2$  percent. The temperature drift rate at constant pressure was about 0.001 K/sec. The pressure drift was negligible.

The analog signals were fed to a data collection system (fig. 5) where they were multiplexed, digitized, and recorded on magnetic tape. Digital data were also fed to a local computer for on-line conversion to engineering units and display on a cathode-raytube (CRT) screen with 1-second updating in the test control console. This on-line, real-time, updated and reduced data display helped to make the control on the experiment so precise. It was possible to monitor the CRT until the exact desired stagnation temperature condition was attained and then to record data on the high-speed data acquisition system.

All thermophysical properties used for data reduction were taken from reference 16, a versatile and accurate computer program.

#### RESULTS

A major result of this experiment is the acquisition of two-phase choked flow data in subcooled liquid oxygen. To the knowledge of the authors, these are the only two-phase choked flow data for liquid oxygen in existence. A second result was the acquisition of both liquid nitrogen and liquid oxygen data along the same reduced isotherms by using the same test sections in the same facility. In an earlier work (ref. 10), which established the validity of a flow-normalizing parameter, it was not possible to duplicate isotherms as accurately as in the present experiment.

The experiment covered a range in stagnation temperature isotherms from 0.61 to 1.67 times the thermodynamic critical temperature. The stagnation pressure ranged from near saturation to within twice the thermodynamic critical pressure. For oxygen this means pressures as high as  $1000 \text{ N/cm}^2$ . The data isotherms covered are summarized in table III. The data are all summarized in tables IV to VII.

Selected data isotherms from the tables for choked flow rates and pressure ratios of oxygen and nitrogen are shown in figure 6. They are all taken from the data for the conical nozzle. In general, only those data points that fall within  $\pm 0.002 T_c$  along a given isotherm were used, even though the tables may contain more points. This means that all the data shown in figure 6 agree along a given isotherm to within  $\pm 0.3$  K. An examination of figure 6 shows that, in reduced coordinates, oxygen and nitrogen two-phase choked flow data fall exactly on top of each other. A careful examination of this figure shows this correspondence to be true even in the areas where there is anomalous behavior that may be due to the particular nozzle geometry, for example, in the low-pressure region of  $T_r = 0.866$  (figs. 6(b) and (f)). The use of G\*, equation (1), as a normalizing parameter to relate nitrogen and oxygen choked flow data seems clearly established. The reducing parameters used herein are given in table VIII.

There are a couple of data points in figure 6 that stand out as not following the data trend. For instance, in figure 6(e) at  $T_r = 0.749$  and  $P_r = 1.76$ , the pressure ratio is about 50 percent above the data trend. There is no evidence in the data record of anything amiss, nor is this random scatter. It is probably some metastable anomaly in the flow. It did not repeat or persist. On the other hand, the 7 percent blip in the pressure ratio data in figure 6(h) at  $T_r = 1.025$  and  $P_r = 0.95$  seems to be phenomologically related to nonequilibrium nozzle dynamics. It was reproduced in another reading and was also noticed on the CRT display during oxygen runs but was not recorded on data tape.

The data taken in separate test sections with oxygen are compared in figures 7(a) and (b). The choked flow rates (fig. 7(a)) in the two nozzles for the same conditions are virtually identical. The flow rates may average 1 to 2 percent higher for the elliptical nozzle than for the conical nozzle, which is consistent since the mean temperature of the elliptical nozzle data is slightly lower. However, this is all within the error level of the experiment. In the case of the pressure ratio (fig. 7(b)), however, the conical nozzle data are about 15 percent above the elliptical nozzle data. (The reader should not be misled by the scale of the figure. The difference is a pretty steady 15 percent over the entire stagnation pressure range.) This may be due to differences in the location of the 'throat' pressure tap or to differences in the nozzle contours. The whole question of the sensitivity of pressure ratio measurements is explored in detail by R. J. Simoneau of Lewis (private communication). For this report it is adequate to point out that at-

tempts to compare choked flow data with theory are destined to yield wide variations in pressure ratio results. In any case, the excellent agreement in flow rates between the two nozzles gives considerable confidence in the accuracy of the experimental measurements.

. .. . ... . . . . . .

Finally in figures 8(a) and (b), the data taken with nitrogen in the conical nozzle at the Plum Brook Station are compared with unpublished data taken under the same circumstances in the Lewis Research Center facility by Simoneau. In this case fluid nitrogen data from the same nozzle were compared in two entirely separate experimental test facilities. The results are in good agreement. The present flow rate data are about 1 to 3 percent below the data of Simoneau. The pressure ratios are virtually identical. Not only does this comparison provide confidence in the test results, it also demonstrates that the anomalies observed are in no way related to the test facility or procedure.

#### CONCLUSIONS

An experiment has been conducted in which two-phase choked flow of liquid oxygen and liquid nitrogen was measured. The tests on both fluids were conducted in the same facility under the same reduced operating conditions and in the same test nozzles. Two converging-diverging nozzles having different contours were used. The experiment was conducted to obtain liquid oxygen data and to examine the validity of the use of corresponding-states parameters in two-phase choked flow of subcooled oxygen.

The result of the experiment is a tabulation of extensive two-phase choked flow data for oxygen and nitrogen covering a range of stagnation parameters:

 $0.61 \le T_0/T_c \le 1.67$ 

$$P_{sat}/P_c < P_0/P_c \le 2.0$$

where  $T_0$  is the stagnation temperature,  $T_c$  is the thermodynamic critical temperature,  $P_{sat}$  is the saturation temperature,  $P_c$  is the thermodynamic critical pressure, and  $P_0$  is the stagnation pressure.

From these data it can be concluded that the two-phase choked flow rates and pressure ratios of subcooled oxygen and nitrogen can be normalized in a correspondingstates manner. The flow rate data were correlated by using the normalizing parameter

$$G^* = \sqrt{\frac{\rho_c P_c}{Z_c}}$$

where  $\rho_{\rm C}$  is the thermodynamic critical density and  $\rm Z_{\rm C}$  is the critical compressibility factor.

Lewis Research Center, National Aeronautics and Space Administration, Cleveland, Ohio, 506-25.

## REFERENCES

- Schmidt, Harold W.; and Forney, Donald E.: ASRDI Oxygen Technology Survey. Volume 9: Oxygen Systems Engineering Review. NASA SP-3090, 1975.
- 2. Mann, Douglas B.: ASRDI Oxygen Technology Survey. Volume 6: Flow Measurement Instrumentation. NASA SP-3084, 1974.
- 3. Hsu, Yih-Yun: Review of Critical Flow, Propagation of Pressure Pulse, and Sonic Velocity in Two-Phase Media. NASA TN D-6814, 1972.
- Henry, R. E.; Grolmes, M. A.; and Fauske, H. K.: Pressure Drop and Compressible Flow of Cryogenic Liquid-Vapor Mixtures. Heat Transfer at Low Temperatures, Walter Frost, ed., Plenum Press, 1975, pp. 229-259.
- 5. Smith, R. V.: Critical Two Phase Flow for Cryogenic Fluids. (NBS-TN-633, National Bureau of Standards; Order W-13300.) NASA CR-130793, 1973.
- Hendricks, R. C.; Simoneau, R. J.; and Ehlers, R. C.: Choked Flow of Fluid Nitrogen with Emphasis on the Thermodynamic Critical Region. Advances in Cryogenic Engineering, Vol. 18, K. D. Timmerhaus, ed., Plenum Press, 1973, pp. 150-161.
- Hendricks, R. C.; Simoneau, R. J.; and Hsu, Y. Y.: A Visual Study of Radial Inward Choked Flow of Liquid Nitrogen. Advances in Cryogenic Engineering, Vol. 20, K. D. Timmerhaus, ed., Plenum Press, New York, 1975.
- Simoneau, Robert J.: Two-Phase Choked Flow of Subcooled Nitrogen Through a Slit. Proceedings of Tenth Southeastern Seminar on Thermal Sciences, R. G. Watts and H. H. Sogin, eds.; Toulane Univ. Press, 1974, pp. 225-238.
- Simoneau, R. J.: Maximum Two-Phase Flow Rates of Subcooled Nitrogen Through a Sharp-Edged Orifice. Presented at 1975 Cryogenic Eng. Conf., Kingston, Ontario, July 22-25, 1975, paper L-2.

- Hendricks, R. C.; and Simoneau, R. J.: Application of the Principle of Corresponding States to Two-Phase Choked Flow. Presented at 74th Natl. Am. Inst. Chem. Engrs., New Orleans, Mar. 1973.
- 11. Hendricks, Robert C.: Normalizing Parameters for the Critical Flow Rate of Simple Fluids Through Nozzles. Proceedings of Fifth International Cryogenic Engineering Conference, Cryogenic Assoc. of Japan, 1974.
- 12. Guggenheim, Edward A.: Thermodynamics; An Advanced Treatment for Chemists and Physicists. Interscience Publ., 1949.
- 13. Obert, Edward F.: Concepts of Thermodynamics. McGraw-Hill Book Co., Inc., 1960.
- Bankaitis, H.; and Schueller, Carl F.: ASRDI Oxygen Technology Survey. Volume 2: Cleaning Requirements, Procedures, and Verification Techniques. NASA SP-3072, 1972.
- Fluid Meters, Their Theory and Application. 6th ed., Howard S. Bean, ed., Am. Soc. Mech. Engrs., 1971, p. 216.
- 16. Hendricks, Robert C.; Baron, Arne K.; and Peller, Ildiko C.: GASP: A Computer Code for Calculating the Thermodynamic and Transport Properties for Ten Fluids: Parahydrogen, Helium, Neon, Methane, Nitrogen, Carbon Monoxide, Oxygen, Fluorine, Argon, and Carbon Dioxide. NASA TN D-7808, 1975.

# TABLE I. - CONICAL CONVERGING-DIVERGING NOZZLE

# (a) Dimensions

$Overall \ length, \ cm \qquad \ldots \qquad \ldots \qquad 31.1$
Throat diameter, cm 0.3555±0.0007
Throat area, $cm^2$
Length of constant-area section, cm 1.135 $\pm 0.020$
Length-diameter ratio, $l/d$ 3.20
Radius of curvature, cm $\ldots \ldots 1.77$
Pressure tap diameter, cm 0.051
Convergence half-angle, deg 6.79 $\pm$ 0.05
Divergence half-angle, deg $3.78\pm0.23$

(b) Tap locations (referenced to throat)

I					
	Station	Tap	Axial dis-	Radius,	Ratio of area
			tance,	r,	to throat
			x,	cm	area,
			cm		A/A <sub>t</sub>
	1	0	-9.12		b∝
ĺ		<sup>a</sup> 1	-5.062	0.645	13.18
		$a_2$	-3.066	. 408	5.26
		$a_3$	-2.263	. 312	3.08
	2	4	-1.984	. 279	2.46
I	3	5	-1.692	.244	1.88
	4	6	-1.052	. 178	1.00
l	5	7	536	. 178	1.00
	6	8	185	. 178	1.00
	7	9	. 112	. 185	1.08
	8	10	. 455	. 208	1.37
		$a_{11}$	.940	. 240	1.82
		$a_{12}$	1.933	. 306	2.95
		<sup>a</sup> 13	7.943	. 703	15.61
	9	14	12.939	1.033	33.73
		<sup>a</sup> 15	17.943	1.363	58.79
		$a_{B}$	22.0		c∞

<sup>a</sup>Not connected for this experiment.

<sup>b</sup>Inlet plenum.

<sup>c</sup>Outlet plenum.

# TABLE II. - ELLIPTICAL CONVERGING-DIVERGING NOZZLE

## (a) Dimensions

Overall length, cm
Throat diameter, cm
Throat area, $cm^2$
Length of constant-area section, $cm \dots \dots$
Length-diameter ratio, $l/d$
Curvature (2:1 ellipse)
r <sub>1</sub>
$\mathbf{r}_2$
Pressure tap diameter, cm 0.080
Converging taper (half-angle), deg 10.1
Divergence half-angle, deg 4.00
Diverging taper (half-angle), deg 10.0
Diameter of straight (constant-area) section, cm 0.808

(b) Tap locations (referenced to throat)

Station (tap)	Axial dis- tance, x, cm	Radius, r, cm	Ratio of area to throat area, A/A <sub>t</sub>
$a_0$	-4.605		b <sub>∞</sub>
1	-2.390	0.747	25.82
2	-1.115	. 274	3.47
3	747	.164	1.25
4	297	. 147	1.00
5	150	. 147	1.00
6	. 373	. 216	2.16
7	1.430	. 290	3.89
8	3.942	. 467	10.09
9	6.452	. 721	24.06

<sup>a</sup>Not connected for this experiment. <sup>b</sup>Inlet plenum.

Conica	l-conve	ergence no	Elliptic	al-conv	vergence n	ozzle			
Oxyg	gen	Nitro	gen	Oxyg	gen	Nitrogen			
Reduced	Table	Reduced	Table	Reduced	Table	Reduced	Table		
temper-		temper-		temper-		temper-			
ature,		ature,		ature,	Į –	ature,			
T <sub>r</sub>		т <sub>г</sub>		Tr		т <sub>r</sub>			
				0.611	VI(a)				
				. 628	VI(b)				
						0.645	VII(a)		
0.750	IV(a)	0.749	V(a)	. 749	VI(c)				
				. 810	VI(d)				
				. 854	VI(e)				
. 866	IV(b)	. 868	V(b)	[					
				. 885	VI(f)				
. 942	IV(c)	.942	V(c)						
				. 952	VI(g)				
1.026	IV(d)	1.025	V(d)						
				1.031	VI(h)	1.031	VII(b)		
1.10	IV(e)	1.10	V(e)						
1.20	IV(f)								
1.30	IV(g)								
1.35	IV(h)								
				1.51	VI(i)				
				1.67	VI(j)				

# TABLE III. - SUMMARY OF DATA ISOTHERMS

## TABLE IV. - CONICAL NOZZLE DATA FOR OXYGEN

(a) Reduced temperature, 0.750

Reading	Reduced	Reduced	Stagnation			Pre	ssure	e at s	tatio	n -		1	Ratio of throat	Maximum	Reduced	Saturation	pressure,
iteating	temper-	pres-	tempera-										pressure to	mass flow	mass	Psat	, at -
	ature,	sure,	ture,	1	2	3	4	5	6	7	8	9	stagnation	rate,	flow	Stagnation	Stagnation
	т <sub>г</sub>	Pr	То										pressure,	G <sub>max</sub> ,	rate,	entrony	tempera-
													Pt/P0	$g/(cm^2)(sec)$	G <sub>r</sub>	S.	ture.
																~0	T <sub>0</sub>
																	0
549	0.746	0.224	115.4	114	104	98	70	64	59	45	37	26	0.514	2 700	0.311	76.9	77.5
550	. 746	. 359	115.5	183	160	145	78	73	73	57	46	30	. 400	4 270	. 493	76.2	78.1
551	. 749	. 293	115.9	149	133	123	77	74	70	53	41	28	. 469	3 500	. 404	78.7	80.1
552	. 749	. 429	115.9	218	189	168	80	73	75	60	49	32	. 345	4 900	. 565	77.4	80.1
553	.750	. 495	116.1	251	217	190	82	72	76	61	51	36	. 303	5 450	. 629	77.5	80.8
554	. 752	. 564	116.4	287	246	214	85	73	78	63	53	38	. 273	5 950	. 686	78.5	82.6
576	. 751	1.46	114.8	744	618	518	101	62	68	59	51	28	. 092	10 920	1.26	63.8	74.4
577	. 742	1.38	114.9	701	583	489	99	63	68	59	51	51	. 098	10 570	1.22	64.8	75.0
578	.744	1.24	115.2	632	527	443	96	64	70	60	52	53	. 111	9 960	1.15	67.2	76.4
579	.746	1.10	115.4	561	469	396	94	65	71	61	53	52	. 128	9 320	1.07	09.1	77.5
580	. 747	.971	115.6	493	413	350	91	66	73	62 C0	53 54	- 5U - 40	. 147	7 020	. 990	70.0	70.2
501	740	. 630	115.7	420	301	305	89	60	74	62 62	04 52	49	- 1 13	7 140	. 915	74 7	79.8
502	. 749	. 701	115.9	300	302	200	00	09	10	02 61	50	40	. 209	6 2 2 0	718	76.0	80.8
503	751	. 505	116.1	200	100	160	0.0	11	70	60	50	20	203	5 170	596	79.0	81 7
595	752	. 420	116.5	140	100	100	70	75	60	52	41	22	. 540	3 820	440	81.6	82.8
586	754	222	116.8	113	103	123	67	61	55	42	34	20	485	3 190	368	83.7	84.2
587	736	1 76	113 0	805	743	610	106	50	65	55	48	21	. 400	12 000	1.38	58.5	70.4
588	749	562	115.9	286	245	214	82	70	75	61	51	42	. 261	6 040	. 696	76.0	80.0
589	751	700	116.3	356	302	261	86	70	77	64	54	45	. 215	6 930	.799	76.5	81.8
590	. 750	. 767	116.1	390	330	283	88	69	75	63	54	48	. 193	7 350	. 848	74.9	80.7
591	.749	. 836	116.0	425	358	306	89	68	75	63	53	49	. 176	7 750	. 894	73.7	80.1
592	.748	. 904	115.8	459	387	329	91	67	74	63	54	50	. 160	8 1 4 0	. 939	72.5	79.5
593	. 755	.971	116.9	493	416	353	95	71	78	66	56	54	. 158	8 420	. 971	76.9	84.9
594	. 754	1.04	116.7	527	443	376	97	70	77	66	56	54	. 146	8 770	1.01	75.4	83.8
595	. 753	1.11	116.6	562	471	399	99	69	76	65	56	54	. 136	9 090	1.05	74.5	83.5
596	. 752	1.17	116.5	596	499	422	100	69	76	65	55	55	. 128	9 420	1.09	73.3	82.8
597	. 752	1.24	116.5	629	527	444	101	68	76	65		55	. 120	9 730	1.12	72.7	82.7
598	. 752	1.31	116.3	666	557	469	103	68	75	64		56	. 112	10 050	1.16	71.5	82.1
599	. 751	1.38	116.3	700	584	491	105	67	74	64	1	11	. 106	10 340	1.19	70.7	81.8
600	. 751	1.44	116.2	733	611	514	106	67	74	64	54		. 100	10 640	1.23	69.9	81.4
601	. 750	1.52	116.1	770	641	538	108	64	73	63	54	1	. 095	10 920	1.26	69.1	81.1
602	. 750	1.58	116.1	803	669	560	109	66	73	63	54	55	. 091	11 160	1.29	68.4	80.8
603	.750	1.65	116.0	837	698	583	111		73	63	53	55	. 087	11 450	1.32	67.7	80.6
604	. 749	1.71	115.9	871	726	606	112		72	62		26	. 083	11 710	1.35	66.8	80.1
605	. 749	1.79	115.9	907	755	630	114	*	72	62		25	. 079	11 960	1.38	66.2	80.0
606	. 748	1.85	115.9	940	783	653	116	65	71	62	1	23	. 076	12 210	1.41	65.6	79.7
	I	1	1			1	' (b	) Red	luced	ltem	perat	ture,	0.866				· · · · · · · · ·
1	1													10.000		1.00	010.7
555	0.865	1.91	133.8	973	829	711	217	162	176	143		100	0.181	10 960	1.26	108.4	210.7
556	1.864	1.79	133.8	907	174	667	214	163	177	143	110	97	. 195	10 500	1.21	177 5	210.2
559	. 807	1.65	134.3	038	650	674	214	171	102	140	110	95	. 217	9 3 9 0	1.14	179.8	213.0
550	966	1.01	134.1	1700	604	529	207	179	102	140	100	86	260	8 820	1.00	182 7	210.1
560	888	1 24	134.0	630	547	482	205	175	183	149	106	82	200	8 160	. 941	185.5	212 4
561	. 867	1.11	134.0	562	491	437	204	180	184	140	104	78	. 328	7 480	.863	190.6	214.0
562	. 865	969	134 0	492	433	380	200	181	183	136	98	71	. 372	6 740	.777	192.8	211.9
563	.866	.904	134.1	459	407	367	200	184	182	133	96	68	, 395	6 340	.730	196.2	213.5
564	,867	. 836	134.2	425	379	345	200	185	178	128	91	65	, 418	5 910	. 681	199.1	214.2
565	.867	, 765	134.1	389	349	321	196	180	166	119	83	61	. 427	5 460	. 630	200.9	213.7
566	.866	697	1	354	320	294	183	166	148	105	73	57	. 418	5 100	. 588	203.4	213.2
567	.867	. 698		355	320	295	184	166	149	104	73	56	. 419	5 110	. 589	203.8	213.7
568	. 866	. 631		321	288	264	156	140	128	91	65	55	. 400	4 950	. 571	205.3	212.9
569		. 562		286	257	236	136	125	116	85	63	54	. 406	4 620	. 533	207.9	213.2
570		. 496	} ∳	252	228	211	125	113	104	75	58	49	. 411	4 180	. 482	210.0	212.9
571	†	. 426	134.0	216	200	191	136	125	114	89	76	42	. 529	3 300	. 380	212.5	212.7

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#### (c) Reduced temperature, 0.942

Readin,	Reduced	Reduced	Stagnation	ļ		Pr	essu	re at	stati	on -			Ratio of throat	Maximum	Reduced	Saturation	pressure,
	temper-	pres-	tempera-	<b></b> ,	Τ,	1		5	a	7	8	0	pressure to	mass flow	mass	Psat	, at -
	ature.	sure.	ture.	<b>`</b>	1		1	1	0	1	ľ	5	stagnation	rate,	flow	Stagnation	Stagnation
	$T_r$	Pr	To		1		1						pressure,	G <sub>max</sub> .	rale, G	entropy,	tempera-
													0	g/(cm <sup>2</sup> )(sec)	r	s <sub>0</sub>	ture,
										1							T <sub>0</sub>
607	0.940	1.77	145.6	900	790	699	308	265	275	207	142	108	0.305	9 210	1.06	279.2	353 0
608	. 940	1.71	145.5	869	764	678	307	266	274	205	140	105	. 315	8 970	1.03	280.5	351.2
609	. 939	1.62	145.4	824	727	647	305	269	275	204	138	100	. 334	8 610	. 992	283.5	349.7
669	. 942	1.92	145.9	975	851	750	312	263	276	211	145	113	. 283	9 750	1.12	276.0	357.5
670	.941	1.85	145.7	942	822	726	309	263	276	209	144	110	. 293	9 500	1.10	277.2	355.3
672	. 943	1.79	145.7	872	765	679	308	267	210	209	143	105	.306	9 220 8 970	1.06	282.0	354.5
673	. 944	1.65	146.1	838	738	657	310	274	282	207	140	100	. 336	8 640	. 996	290.4	360.5
674	. 941	1.58	145.7	804	709	633	307	273	280	204	138	97	. 348	8 3 9 0	. 967	289.7	355.3
675	. 942	1.51	145.8	769	680	610	308	277	281	201	135	95	. 366	8 05 0	. 928	294.3	356.7
676	.941	1.44	145.7	734	651	586	307	278	279	197	132	91	. 381	7 750	. 893	296.8	355.3
677	. 942	1.38	145.8	700	623	564	307	280	277	192	130	87	. 395	7 410	. 855	300.8	355.6
679	. 942	1.31	145.9	630	566	517	304	279	259	178	156	80	. 410	6 720	. 816	310.4	355.3
680	. 942	1.17	145.8	596	537	492	295	268	242	167	165	78	. 406	6 420	.740	313.8	356.0
681	. 942	1.11	145.8	563	507	466	280	252	225	167	175	75	. 400	6 170	.711	318.3	356.0
682	.941	1.04	145.7	528	476	438	262	235	211	180	185	72	. 399	5 920	. 683	322.6	355.3
683	.941	. 973	145.7	494	447	412	249	227	207	192	196	69	. 420	5 670	. 654	327.9	355.3
684	. 942	. 903	145.8	459	417	386	247	230	217	210	212	65 60	. 474	5 260	. 606	335.4	356.7
686	942	. 630	145.8	389	362	343	253	230	243	238	225	53	623	4 180	482	341.9	356.4
683	.944	.723	146.1	367	347	334	271	266	264	260	241	45	. 718	3 500	. 404	359.9	361.2
L		l			1	l I	I		1	I !			l I				
							(0	i) Re	duceo	l tem	perat	ure,	1.026				
610	1.033	1.91	159.9	972	880	805	460	417	418	382	349	102	0.430	7 630	0.880	434.5	(a)
611	1.031	1.85	159.6	941	854	783	458	419	419	385	347	100	. 445	7 400	. 853	435.8	
612	1.029	1.79	159.2	908	826	760	456	420	419	388	345	97	. 461	7 140	. 823	437.4	
613	1.026	1.71	158.8	870	794	733	454	421	419	391	341	94	. 482	6 840	. 789	439.5	
614	1.025	1.65	158.6	837	766	711	454	424	420	396	336	91	. 502	6 540	. 754	443.0	
616	1.021	1.59	158.8	770	713	669	466	443	442	415	317	81	. 574	5 730	. 661	459.2	
617		1.45	158.9	735	685	648	473	453	454	422	302	76	. 617	5 260	. 606	467.7	
618		1.38	158.9	700	658	626	481	465	467	419	280	70	. 667	4 740	. 546	477.2	
619		1.31	158.8	668	633	607	488	475	478	380	254	63	. 716	4 230	. 488	486.0	
620		1.25		634	606	586	477	426	413	323	220	57	. 651	3 660	. 422	498.1	
621		1.18		600	576	559	419	387	368	279	189	50	. 614	3 100	. 357	506.4	
622		1.12	158.0	508	544	529 488	390	368	349	258	151	45	. 615	2 570	. 297	430.9	
624	1.025	.977	158.7	497	472	455	347	325	301	217	141	35	. 605	2 070	. 239	383.1	
625	1.025	. 905	158.6	460	436	418	298	280	279	211	135	32	. 608	1 900	. 219	327.8	
626	1.026	. 838	158.7	426	402	386	262	241	230	192	124	30	. 541	1 730	. 200	276.6	
627	1.027	. 771	159.0	392	370	355	240	220	209	167	109	28	. 532	1 600	. 184	230.5	
628	1.026	. 704	158.7	358	338	324	218	201	190	137	97	25	.530	1 470	. 169	196.3	
629	1.025	570	158.7	324	300	293	197	162	153	123	68 68	23	527	1 200	138	126.4	
631	1.029	. 573	159.3	291	275	263	176	164	153	110	67	21	. 526	1 160	. 133	125.4	
632	1.026	. 502	158.9	255	240	230	154	143	134	95	56	19	. 524	1 030	. 119	97.9	- f f
633	1.026	. 429	158.8	218	205	197	131	122	113	81	48	17	. 520	910	. 104	72.0	
634	1.027	. 360	158.9	183	172	165	110	102	95	68	40	16	.517	790	. 092	51.5	
635	1.026	. 291	158.8	148	138	132	89	83	-44	55	32	14	. 518	680	. 078	34.8	.
·			,		,		(	e) Re	duced	ltem	perat	ure,	1.10	,	,	1	
			100 0 }									1	0.614	2 000	0.000	450 0	(0)
706	1.10	1.40	169.8	110	072 620	602 602	401	437	436	320	229	50 50	0.014	2 920	0.368	402.0	(a)
708	1.10	1.24	169.6	632	597	570	391	363	352	296	193	45	. 557	2 690	.310	382.6	
709	1	1.17	169.9	596	564	539	363	333	314	267	176	41	. 527	2 460	. 284	341.5	
710		1.11	169.6	562	532	508	343	314	295	242	160	39	. 524	2 300	. 265	307.7	
711		1.04	169.9	529	500	478	323	296	277	214	145	37	.524	2 160	.249	021 5	
712	1 00	. 966	169 9	491	463	444	300	275	258	182	131	35	. 526	2 000	230	231.7	
713	1.10	837	169.4	409	402	385	261	239	223	157	109	30	. 526	1 750	. 201	176.8	
715	1.09	.769	169.4	391	369	354	241	220	206	144	93	27	. 527	1 580	. 182	151.0	
716	1.10	. 702	170.2	357	337	323	219	202	188	131	79	25	. 526	1 420	. 163	121.6	
717	I I	. 631	169.9	321	303	290	198	181	169	119	71	23	. 528	1 280	. 148	99.3	
718		.567	169.7	288	272	261	177	162	152	106	64	21	. 526	1 160	. 134	81.0	
719		. 496	169.9	252	237	228	155	142	132	93	55 4P	19	. 526	1 040	. 120	61.8	
720		. 430	169.9	183	205   179	165	134	123	96	67	40	15	. 524	920 770	. 089	34.1	
722		. 291	169.7	148	139	133	90	83	77	54	32	14	. 521	660	. 077	23.4	
723	*	. 226	169.7	115	107	103	70	64	60	42	25	12	.518	580	. 066	15.4	* [
Ļ]	1	i	]			1	1		I	1	I	I	1	1	I	1	I
<sup>4</sup> Not appli	cable																

#### TABLE IV. - Combided

(f) Reduced temperature, 1-20

$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	Reading	Reduced	Reduced	Stagnation	1		Pre	ssur	e at s	-tatic	n -		1	Ratio of throat	Maximum	Reduced	Saturation	pr(ssure,
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		temper-	pres-	tempera-		Ι.		Ι.						pressure to	mass flow	mass	P <sub>bat</sub>	at -
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		ature,	sure,	ture,	1	2	3	4	5	6	7	8	9	$sta_boation$	rate,	flow		
error         p <td></td> <td>т<sub>r</sub></td> <td>Pr</td> <td>то</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td>pressure,</td> <td>G<sub>max'</sub></td> <td>rate.</td> <td>Stagnation</td> <td>stagnation</td>		т <sub>r</sub>	Pr	то										pressure,	G <sub>max'</sub>	rate.	Stagnation	stagnation
ess         1.22         1.23         1.24         1.24         1.24         1.24         1.25	1					Į								PtP0	g '(cm <sup>2</sup> )(sec)	G <sub>r</sub>	entropy.	turo
630         1.22         1.23         188.9         05         562         563         576         377         255         139         46         7.328         2         130         230         171         100           637         1.21         1.17         197.4         566         330         333         223         122         44         3544         2 470         230         171         100           630         1.11         105.6         560         330         333         223         122         44         3544         1240         130         131         130         131         140         130         131         140         130         131         140         130         140         130         140         130         131         140         130         131         140         130         131         140         140         130         131         140         130         131         140         130         131         140         130         131         140         130         131         140         130         131         140         130         131         140         130         131         140         130 <th< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>°0</td><td>To</td></th<>																	°0	To
Geo         1.22         1.22         1.22         1.22         1.22         1.23         1.24 <th< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>i i</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>Ч<u> </u></td></th<>								i i										Ч <u> </u>
err       1.21       1.17       187.4       666       586       328       328       322       321       324       43       554       2070       2.290       170.6         G60       1.00       148.3       540       513       503       328       522       527       520       151       555       1670       2.35       153.5       577       1698       155       557       1698       1570       153.5       66.1       160.6       160.5       1570       1598       1510       153.5       66.1       160.6       160.5       159       151.6       1510       153.5       66.1       160.6       160.5       159       151.6       1510       1518       1510       1513 </td <td>636</td> <td>1.22</td> <td>1.23</td> <td>188.9</td> <td>625</td> <td>592</td> <td>565</td> <td>376</td> <td>347</td> <td>327</td> <td>235</td> <td>139</td> <td>45</td> <td>0.528</td> <td>2 180</td> <td>0 251</td> <td>187.3</td> <td>(a)</td>	636	1.22	1.23	188.9	625	592	565	376	347	327	235	139	45	0.528	2 180	0 251	187.3	(a)
ergs       1.20       1.12       1.20       1.20       1.21       1.20       1.21       1.20       1.21       1.20       1.21       1.20       1.21       1.20       1.20       1.20       1.20       1.20       1.20       1.20       1.20       1.20       1.20       1.20       1.20       1.20       1.20       1.20       1.21       1.22       1.21       1.21       1.21       1.21       1.21       1.21       1.21       1.21       1.21       1.21       1.21       1.21       1.21       1.21       1.21       1.22       1.22       1.22       1.22       1.22       1.22       1.22       1.22       1.22	637	1.21	1.17	187.4	596	564	538	358	332	312	223	132	43	. 524	2 070	. 239	179.1	
Gap         1.06         16.0         360         11.44         322         320         120         120         327         150         155.0           Gap         972         155.0         444         644         555         110         35         527         1500         155         111.4         155.0	638	1.20	1.12	185.6	563	533	509	339	313	295	212	125	40	. 524	1 960	. 226	170 6	
	639		1.06	186.3	540	511	488	325	301	283	203	120	38	. 525	1 870	. 215	153.0	
eta	640		. 972	185.5	494	467	446	297	275	260	185	110	35	. 527	1 690	. 195	131.4	
esc	641		. 841	185.9	427	403	385	200	231	225	145	95	20	. 326	1 430	140	70.9	
excl b66         cost cost cost cost cost cost cost cost	642		606	196.2	254	300	320	213	197	186	132	79	25		1 1 70	135	66 1	
esc         .564         156.0         237 (71)         269 (71)         211         0.925         950         110         44.2         44.2           646         .460         186.0         212         205         107         131         211         14         81         47         552.4         650         .068         25.2           648         .202         185.8         149         159         134         82         77         55         221         14         .519         540         .070         224.1         .1         1.66         151.2         229         1.68         151.2         221.0         .677         224.1         .1         1.20         152.4         474         441         282         282         282         282         164         21         .520         1530         .244         129.6         .277         .21         .307         1830         .307         183         .133         .512         .220         .637         183         .41         .285         .221         .207         .207         .20         .207         .207         .20         .201         .201         .201         .201         .201         .201         .221	644		633	185.6	322	303	290	194	179	169	120	71	23	∳	1 080	. 124	55.9	
sec	645		. 564	186.0	287	271	259	173	159	151	107	63	21	. 525	950	. 110	44.2	
err        30         186.0         121         114         81         81         17        322         740         .085         26.7           646        301         185.8         149         134         183         121         14         81         82         77         55         22         14         .519         54-0         .073         22.0.0         143.2           724         1.11         1.77         152.6         666         70         542         258         228         164         42         .566         2.500         .470         284.1           728         1.12         1.20         152.4         474         64         431         289         282         176         12         35         .512         2.210         .307         12.8         .44         1.80         1.80         130         .520         1.50         .424         1.80         .520         1.52         .221         .66         .52         .523         1.200         .131         .58         1.30         .512         .2210         .53         .54         1.00         .166         .5.5         .533         .524         1.00         .160         .55.5 </td <td>646</td> <td></td> <td>. 498</td> <td>185.8</td> <td>253</td> <td>238</td> <td>228</td> <td>153</td> <td>140</td> <td>132</td> <td>94</td> <td>55</td> <td>19</td> <td>. 524</td> <td>850</td> <td>. 098</td> <td>35.2</td> <td></td>	646		. 498	185.8	253	238	228	153	140	132	94	55	19	. 524	850	. 098	35.2	
648         I         .88         172         166         101         .921         649         105         .921         640         .071         20.0           724         1.21         1.66         153.4         668         697         993         332         252         166         47         .486         2.880         .470         284.1           725         1.11         1.77         152.4         474         418         282         271         121         .605         2.290         .420         237.7           1.20         1.40         152.4         473         641         288         824         715         121         35.18         1300         .254         129.0         .254         129.0         .254         129.0         .254         129.0         .254         129.0         .254         129.0         .254         129.0         .254         129.0         .254         129.0         .254         129.0         .254         129.0         .254         129.0         .254         129.0         .555         .56         .233         14         .520         .279         .254         129.0         .553         121         120.0         .553 <td< td=""><td>647</td><td></td><td>. 430</td><td>186.0</td><td>218</td><td>205</td><td>197</td><td>131</td><td>121</td><td>114</td><td>81</td><td>48</td><td>17</td><td>. 522</td><td>740</td><td>. 085</td><td>26.7</td><td></td></td<>	647		. 430	186.0	218	205	197	131	121	114	81	48	17	. 522	740	. 085	26.7	
6 669f	648		. 361	185.9	184	172	166	110	102	96	68	40	15	. 521	640	. 073	20.0	
124       1.96       153.4       6.86       605       607       304       332       324       332       324       332       324       332       324       332       324       332       324       332       325       225       240       140       150       479       224.1       150       2250       479       224.1       150       367       228.1       141       150       367       228.1       151       150       150       367       228.1       151       150       367       228.1       151       150       367       228.1       164       120       120       151       160       150       227.7       120       150       166       150       227.7       120       150       166       150       227.1       150	649	1	. 292	185.8	149	139	134	89	82	77	55	32	14	. 519	540	. 062	14.2	
125       1.21       1.77       152.6       6.49       570       52.50       4.27       257.7       1         726       1.20       1.60       153.4       4.77       481       481       282       274       151       153.0       .228.4       175       123       5.18       1830       .256       .228.4       129.6       .277       1.21       1.00       152.5       343       325       310       281       166       153.0       .250       153.0       .257       153.0       .267       169.7       .77         730       1.20       .618       152.0       211       200.19       129       118       11.7       74       17       555       790       .131       35.8         730       1.20       .648       152.0       211       200.523       1390       0.160       65.5       (a)         650       1.20       .677       423       491       400       207       246       221       157       33       551       1390       0.160       65.5       (a)         652       1.20       1.43       494       402       200.7       426       222       157       551       100 </td <td>724</td> <td>1.21</td> <td>1.96</td> <td>153.4</td> <td>668</td> <td>629</td> <td>597</td> <td>391</td> <td>354</td> <td>332</td> <td>252</td> <td>186</td> <td>47</td> <td>. 496</td> <td>2 880</td> <td>. 479</td> <td>284.1</td> <td></td>	724	1.21	1.96	153.4	668	629	597	391	354	332	252	186	47	. 496	2 880	. 479	284.1	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	725	1.21	1.77	152.6	604	570	542	358	325	305	228	166	42	. 505	2 520	. 420	257.7	
$\begin{array}{c c c c c c c c c c c c c c c c c c c $	726	1.20	1.60	151.9	547	517	492	328	297	280	199	146	39	.512	2 210	. 367	228.4	
1729       1.2.1       1.00       152.8       142.399       312.290       226       142.392       300       .520       1.530       .224       129.6         739       1.2.0       8.14       151.2       278       263       120       161       162       167       55       533       1.260       .274       129.6         731       1.2.0       .643       151.2       271       21.20       .642       151.8       164       103       22       1.30       .66       62.9       1.30       .66       65.9       1.30       .66       65.9       1.30       .66       .65.9       .13.0       .66       .65.9       .13.0       .60       .65.5       .66       .66.9       .13.0       .66       .65.9       .13.0       .66       .61.1       .13.0       .66       .65.5       .13.0       .13.0       .66       .61.5       .60.1       .61.3       .77.25       .52.1       .10.0       .13.7       .74.1       .10.0       .13.7       .74.1       .13.0       .66       .24.4       .22.2       .25.2       .27.3       .29.6       .21.1       .21.1       .21.1       .22.1       .22.1       .22.1       .22.1       .22.1       .22.1	727	1.21	1.40	152.4	477	451	431	289	263	247	175	121	35	. 518	1 830	. 305	176.5	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	728	1.21	1.20	152.8	412	389	372	200	228	214	152	92	30	. 520	1 530	. 254	129.6	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	729	1.21	1.00	152.5	343	325	310	209	155	140	128	76	20	523	1 250	. 207	62 0	
$ \begin{array}{c c c c c c c c c c c c c c c c c c c $	730	1.20	. 814	151.2	218	203	101	120	100	140	70	02 47	17	524	1 100	. 100	25.9	]   [
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	731	1.20	429	152.0	146	1 1 3 8	133	89	81	76	54	31	14	520	590	. 131	18.4	i 🕴 1
Up Reduced temperature, 1 30         650       1 30       0.872       200.5       443       419       400       256       221       157       93       30       521       1 320       153       58.1       (a)         651       .766       0.00       356       336       121       107       93       100       127       111       191       46.1         653       .069       200.6       356       336       121       100       127       41.1       100       127       41.1       104.1       110       127       41.1       104.1       110       122       121       152.1       150       100       147       141.1       100       127       41.1       110       122       121       121       121       121       121       121       122       121 <t< td=""><td>1 132</td><td>1.20</td><td>. 125</td><td>151.0</td><td></td><td>1.00</td><td>1.00</td><td>00</td><td></td><td></td><td></td><td></td><td>1.</td><td></td><td>1</td><td></td><td>10.1</td><td></td></t<>	1 132	1.20	. 125	151.0		1.00	1.00	00					1.		1		10.1	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$								(g	() Ree	duced	l tem	perat	ure,	1 30				
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	650	1 30	0 872	200.5	443	419	400	267	246	232	165	97	32	0.523	1 390	0.160	63.5	(a)
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	651	1 30	876	200.7	425	401	383	256	236	221	157	93	30	521	1 320	153	58 1	,
653         6.99         20.6         555         352         322         304         291         196         181         188         113         70         23         .521         950         .109         34.0           655         .563         200.7         322         304         291         196         181         188         197         70         23         .521         950         .109         34.0           656         .668         200.7         217         741         160         141         105         62         21         .521         950         .084         22.2         .           656         .498         200.7         149         140         185         77         27         .0522         730         .084         20.0         .         .         .         .         .         .         .         .         .	652		.766	200.6	389	368	352	236	218	204	144	85	28	. 523	1 210	. 139	49.1	
6546.5320.0.732230429110616116811970235215501.0034.0655	653		. 699	200.6	355	336	321	216	200	185	131	77	25	. 521	1 100	. 127	41.1	
665656	654		. 633	200.7	322	304	291	196	181	168	119	70	23	. 521	950	. 109	34.0	
656         .498         200.7         253         229         154         142         152         93         15         19         .522         730         .004         22.2           657	655		. 563	200.8	286	270	259	174	160	149	105	62	21	. 521	830	. 096	27.4	
657       .427       200.7       217       244       196       132       122       113       80       47       18       521       610       .011       17.1         658       .366       200.5       183       172       166       151       0.058       13.0         659       .223       200.7       149       140       135       91       83       77       54       32       14       .518       400       .046       10.1         660       .226       200.6       115       107       104       70       64       59       41       24       13       .514       290       .033       10.1       .11         660       .226       200.6       115       107       106       55       519       1400       .068       132       (11)       .517       152       2000       230       74.3         538       1.45       138       224.6       700       666       636       359       354       324       356       271       144       512       2000       230       74.3       540       143       140       140       512       100       153       113 <td< td=""><td>656</td><td></td><td>. 498</td><td>200.7</td><td>253</td><td>239</td><td>229</td><td>154</td><td>142</td><td>132</td><td>93</td><td>55</td><td>19</td><td>. 522</td><td>730</td><td>. 084</td><td>22.2</td><td></td></td<>	656		. 498	200.7	253	239	229	154	142	132	93	55	19	. 522	730	. 084	22.2	
668	657		. 427	200.7	217	204	196	132	122	113	80	47	18	. 521	610	. 071	17.1	
659       . 293       200. 7       149       140       135       91       83       77       54       32       14       .518       290       .033       10. 1         bit Reduced temperature.       1.35         bit Reduced temperature.       1.35         536       1.41       0.698       217. 6       355       336       322       217       198       185       129       77       27       0.522       990       0.114       24.8       (a)         537       1.40       0.698       217.6       355       391       354       326       227       134       45       .517       1800       .162       47.3       533       1.44       1.24       22.0       630       666       53       394       356       247       147       49       512       2000       23.0       74.3       144       14       124       22.2       631       600       574       393       356       221       124       1512       1790       .206       63.6       54       143       139       512       1790       .206       63.6       54       133       1368       182       183       1830	658		. 360	200.5	183	172	166	112	102	95	67	39	16	. 517	510	. 058	13.0	
660       1       1.2.0       200.0       11.5       10       10       03       31       12       13       .5.14       2.5.9       1.3.3       10.1       1         (h) Reduced temperature.       1.35         (h) Reduced temperature.       1.360       1.14       24.8       (h)       136       315       16.1       17       13       14       1400       166.5       17.1       162       17.1       163       163       163	659		. 293	200.7	149	140	135	91	83	50	54	32	14	.518	400	.046	10.1	
th Reduced temperature. 1.35         536       1.41       0.698       217.6       355       336       322       217       198       185       129       77       27       0.522       990       0.114       24.8       (a)         537       1.40       .969       216.5       492       467       446       306       277       256       179       105       35       .519       1.400       .162       47.3       1.65       138       1.42       1.24       220.4       630       599       573       391       356       371       174       49       512       2000       230       74.3       1.66       1.65       514       1.11       124       222.9       631       600' 574       393       356       323       222       132       44       512       1.790       .206       63.6       1.65       544       1.380       .159       44.9       1.513       1.580       1.59       44.9       1.513       1.514       1.380       1.52       54.0       1.55       544       1.37       1.66       2.55       2.513       1.190       1.37       36.6       1.55       54.0       1.55       546       1.36	660	•	. 220	200.6	115	107	104	10	04	59	41	24	1.5	. 514	290	.033	10.1	· '
536       1.41       0.698       217.6       355       36       322       217       198       185       129       77       27       0.522       990       0.114       24.8       (a)         537       1.40       .969       216.5       492       467       446       306       277       256       179       105       35       .519       1400       .162       47.3         538       1.42       1.24       220.4       630       599       573       394       356       227       134       45       .517       1820       210       68.5       5         540       1.44       124       222.9       631       600       574       335       356       323       221       1790       .206       63.6       5         541       1.43       1.01       220.6       661       534       513       1300       159       449       44       512       1790       .206       63.6       5         541       1.43       1.99       218.2       492       488       30       514       1190       .137       36.6       6       5       5       5       5       5 <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>61</td><td>i) Ree</td><td>duceo</td><td>i tem</td><td>perat</td><td>ure.</td><td>1.35</td><td></td><td></td><td></td><td></td></td<>								61	i) Ree	duceo	i tem	perat	ure.	1.35				
537       1.40       969       216.5       492       467       446       306       277       256       179       105       35       519       1       400       .162       47.3         538       1.42       1.24       220.4       630       599       573       31       354       262       27       134       45       517       1.820       210       68.5         539       1.45       1.38       224.6       700       666       636       435       394       358       247       147       45       512       2000       230       74.3         540       1.44       1.24       222.9       631       600'       574       335       356       325       356       325       317       320       34       514       1.380       .182       54.0         543       1.39       835       215.5       424       402       356       231       117       39       .513       1.900       .115       29.0         543       1.37       .698       212.2       355       337       323       222       202       182       141       190       .115       29.0       .514 <td>536</td> <td>1.41</td> <td>0,698</td> <td>217.6</td> <td>355</td> <td>336</td> <td>322</td> <td>217</td> <td>198</td> <td>185</td> <td>129</td> <td>77</td> <td>27</td> <td>0,522</td> <td>990</td> <td>0.114</td> <td>24.8</td> <td>(a)</td>	536	1.41	0,698	217.6	355	336	322	217	198	185	129	77	27	0,522	990	0.114	24.8	(a)
538       1.42       1.24       220.4       630       599       573       391       354       326       227       134       45       .517       1.820       210       68.5         539       1.45       1.38       224.6       700       666       636       435       394       356       232       221       132       44       512       2000       230       74.3         540       1.44       1.24       222.9       631       600       574       393       356       232       221       132       44       512       2000       230       74.3         541       1.43       1.10       220.6       551       534       513       158       182       173       39       513       180       182       184       9       183       182       184       9       183       182       193       44.9       137       36.6         542       1.41       .969       212.2       355       337       323       222       202       183       133       514       1 190       137       36.6         543       1.33       .910       .614       107       55       513	537	1.40	.969	216.5	492	467	446	306	277	256	179	105	35	. 519	1 400	. 162	47.3	
539       1.45       1 38       224.6       700       666       636       435       394       358       247       147       49       512       2 000       230       74.3         540       1.44       1 24       222.9       61       600       574       333       356       332       222       132       14       512       1 700       .206       63.6       63.6         541       1.43       1.0       220.6       561       534       513       1580       .1182       54.0         542       1.41       .969       218.2       492       462       255       221       131       100       34       514       1 380       .159       44.9       63       514       1 90       .137       36.6         543       1.37       .698       212.2       255       337       322       220       121       21       151       138       100       137       36.6       290       215       513       1000       .137       36.6         544       1.33       .291       205.6       148       130       134       92       14       10       105       921       151       45	538	1.42	1.24	220.4	630	599	573	391	354	326	227	134	45	. 517	1 820	210	68.5	
540       1.44       1.24       222.9       631       600' 574' 393' 356' 323' 222' 132' 44'       .512       1.790'       .206'       63.6         541       1.43       1.10       220.6       561' 534' 511' 350' 318' 288' 198' 117' 39'       .513'       1.580'       .182' 54.0         542       1.41'       .969'       218.2       422' 468' 448' 308' 279' 253' 173' 102' 34'       .514'       1.380'       .159' 44.9         543       1.39'       .635'       215.5'       424' 402' 385' 262' 21' 218' 149' 88' 30'       .514'       1.190''       .137''       36.6         544       1.37''       .698''       212.2''       255'''       .513'''       10''''       .513'''''       10''''''''''''''''''''''''''''''''''''	539	1.45	1 38	224.6	700	666	636	435	394	358	247	147	49	512	2 000	230	74.3	;
541       1.43       1.10       220.6       561       534       511       350       318       288       198       117       39       .513       1580       .182       54.0         542       1.41       .969       218.2       492       468       448       309       270       253       173       102       34       .514       1380       .159       44.9       449       543       1.35       215.5       424       402       355       212       121       149       88       30       .514       1190       .137       36.6       544       1.35       .564       209.0       .115       29.0       .115       44.9       21       .117       73       .513       10.00       .115       29.0       .153       .100       .115       29.0       .154       113.7       .512       .533       .073       14.3       .143       .143       .143       .143       .143       .143       .143       .143       .143       .143       .143       .143       .167       .165       .522       10.0       .116       .166       .166       .166       .163       .265       .252       1000       .1164       .161       .166 <td>540</td> <td>1.44</td> <td>1 24</td> <td>222.9</td> <td>631</td> <td>600</td> <td>574</td> <td>393</td> <td>356</td> <td>323</td> <td>222</td> <td>132</td> <td>44</td> <td>. 512</td> <td>1 790</td> <td>. 206</td> <td>63.6</td> <td></td>	540	1.44	1 24	222.9	631	600	574	393	356	323	222	132	44	. 512	1 790	. 206	63.6	
542       1.41       .969       218.2       492       468       406       279       253       173       102       34       .514       1 380       .159       44.9         543       1.39       .835       215.5       424       402       385       225       221       122       122       122       122       122       122       122       122       122       122       122       122       122       122       122       122       122       121       137       36.6       136       1300       115       29.0       135       35.64       133       120       131       100       59       21       .513       1000       .115       29.0       143       36.6       14       130       14.3       310       094       21.4       143       36.6       10.1       143       30       14       511       450       .052       10.1       143       30       144       40       28.3       10       14       514       510       145       10.1       .56       10.1       .56       205.0       79       74       149       44       47       71       62       .502       .522       10.0 <td< td=""><td>541</td><td>1.43</td><td>1.10</td><td>220.6</td><td>561</td><td>534</td><td>511</td><td>350</td><td>318</td><td>288</td><td>198</td><td>117</td><td>39</td><td>. 513</td><td>1 580</td><td>. 182</td><td>54.0</td><td></td></td<>	541	1.43	1.10	220.6	561	534	511	350	318	288	198	117	39	. 513	1 580	. 182	54.0	
543       1.38       .635       215.5       424       402       285       265       241       218       149       88       30       .514       1190       .137       36.6         544       1.37       .698       212.2       355       337       323       222       202       182       124       73       25       .513       1000       .115       29.0         545       1.35       .564       209.6       287       272       221       110       76       513       11       700       .911       513       810       .073       14.3         546       1.34       .428       207.4       217       205.6       148       139       134       92       83       76       51       30       14       .511       450       .052       10.1         546       1.32       .156       205.0       79       74       71       49       44       027       16       12       .504       310       .036       10.1         561       1.35       .692       208.5       252       201       183       167       15       504       .091       21.8       .515       690	542	1.41	.969	218.2	492	468	448	308	279	253	173	102	34	. 514	1 380	. 159	44.9	
544       1.37       .698       212.2       235       337       232       222       202       182       124       73       25       .513       1000       .115       29.0         545       1.35       .564       209.6       287       722       261       180       163       147       100       59       21       .513       810       094       21.4         546       1.34       .428       207.4       217       272       283       76       51       30       14       .511       450       .052       10.1         546       1.32       .156       206.0       79       74       71       49       44       07       76       25       .522       1000       .168       11.1         661       1.35       .6692       208.5       352       333       319       217       181       142       12       504       310       .036       10.1         663       .560       208.5       282       205       102       118       167       115       68       23       .519       900       .104       27.1         6664       .497       208.5       282	543	1.39	. 835	215.5	424	402	385	265	241	218	149	88	30	.514	1 190	. 137	36.6	
545       1.35       .064       209.6       287       272       291       180       163       147       100       59       21       .513       810       094       21.4         546       1.34       .428       207.4       217       205       188       136       123       111       76       55       17       .512       630       .073       14.3         547       1.33       .291       205.6       148       139       134       92       83       76       51       30       14       .511       450       .052       10.1         548       1.32       .156       205.0       79       74       71       49       44       40       27       16       12       .504       310       .036       10.1         661       1.35       .692       208.5       352       333       319       217       168       184       128       76       25       .522       1000       .114       31.6       664         663       .560       208.5       252       238       29       158       144       100       65       13       .515       690       .079       17.8<	544	1.37	. 698	212.2	355	337	323	222	202	182	124	73	25	.513	1 000	. 115	29.0	
547       1.33       .201.4       211.2       100       100       120       111       10       45       11       .512       110       .511       450       .013       14.3         547       1.33       .291       205.6       146       139       134       92       83       76       51       30       14       .511       450       .052       10.1         548       1.32       .156       205.0       79       74       71       49       44       40       27       16       12       .504       310       .036       10.1         661       1.35       .692       208.5       322       305       292       201       183       167       156       625       .522       1000       .116       31.6         663       .560       208.5       252       238       295       171       162       147       101       60       21       .517       790       .091       21.8       666       .358       208.3       182       171       164       138       16       .12       470       .555       59.0       .079       17.8       .666       .358       208.3       182	545	1.35	. 564	209.6	287	272	261	180	163	147	100	59	21	. 513	810	094	21.4	
3-1       1.32       1.52       1.52       1.52       1.50       1.51       1.52       1.51       1.51       1.50       1.52       1.61       1.51       1.50       1.52       1.61       1.51       1.50       1.55       1.61       1.55       1.61       1.55       1.61       1.55       1.61       1.61       1.55       1.62       1.61       1.71       1.61       1.2       1.61       1.2       1.64       1.10       1.736       1.0, 1       1.61       1.66       1.65       1.62       1.63       1.61       1.65	546	1.34	. 428	21/7.4	217	1200	104	130	123	111	10	45	17	. 512	630	.013	14.3	
661       1.35       609       208.5       352       33 39       217       10       12       100       110       111         661       1.35       .692       208.5       352       33 39       217       10       81       12       100       116       31.6       662         663       .560       208.5       285       269       291       177       162       147       10       60       517       739       091       21.8       666         664       .497       208.5       252       228       249       144       130       90       53       19       177       162       147       10       60       53       900       .104       27.1         664       .497       208.5       252       238       229       18       164       130       905       53       19       515       690       .079       17.8         665       .428       208.3       142       171       165       14       104       93       64       38       65       76       52       31       14       .513       370       .043       10.1         666       .226	547	1.33	. 291	205.0	148	139	134	92 40	03	40	27	18	19	504	430	. 032	10.1	
662       663       208.4       322       305       292       201       183       167       176       68       23       519       900       .104       27.1         663       .560       208.5       285       269       259       177       162       147       101       69       21       .517       799       .091       21.8         664       .497       208.5       252       238       229       158       144       130       90       53       19       .515       690       .079       17.8         666       .428       208.4       217       205       198       132       124       112       46       46       17       .515       580       .067       13.9       90       667       .055       9.9       90       .667       13.9       .93       35       76       52       31       14       .513       370       .043       10,1       10,1       10,1       165       59       40       24       13       .509       270       .055       9.9       .667       .322       208.4       115       107       104       17       65       59       24       13	661	1.32	. 692	208.5	352	333	319	217	198	184	128	76	25	.522	1 000	. 116	31.6	
663         .560         208.5         225         269         259         177         162         147         101         60         21         .517         790         .091         21.8           664         .497         208.5         252         238         229         158         144         130         90         53         19         .515         690         .079         17.8           665         .428         208.4         217         205         198         136         124         112         46         46         17         .515         580         .067         13.9         6666         .358         208.3         149         135         93         85         76         52         21         14         .513         370         .043         10,1           668         .226         208.4         115         107         104         71         65         59         40         24         13         .509         277         .031         10.1           733         1.48         170.5         504         477         455         52.2         21         145         135         51         371         .02         12	662	1.00	. 633	208.4	322	305	292	201	183	167	115	68	23	.519	900	. 104	27.1	
664         .497         208.5         252         238         229         158         144         130         90         53         19         .515         690         .079         17.8           665         .428         208.4         217         205         198         136         124         112         46         46         17         .515         580         .067         13.9         .6667         .358         208.3         182         171         165         114         104         93         64         38         16         .512         470         .055         9.9         .667         .292         208.3         149         135         59         576         52         31         14         .513         370         .043         10.1           668         .226         208.4         115         107         104         71         65         59         40         24         13         .509         277         .031         10.1           734         1.22         170.5         415         393         375         252         231         216         153         51         140         .239         63.0         .230	663		. 560	208.5	285	269	259	177	162	147	101	60	21	. 517	790	. 091	21.8	
665         . 428         208.4         217         205         198         136         124         112         46         46         17         . 515         580         . 067         13.9           666         .358         208.3         182         171         165         114         104         93         64         38         16         .512         470         .055         9.9           667         .292         208.3         149         139         135         93         85         76         52         31         14         .513         370         .043         10.1           668         .226         208.4         115         107         104         16         59         40         24         13         .509         270         .031         10.1           733         1.48         170.3         504         477         46         305         279         261         184         100         5         518         1710         .285         52.2           734         1.22         170.5         415         393         375         252         231         121         122         120         444         .23	664		. 497	208.5	252	238	229	158	144	130	90	53	19	. 515	690	. 079	17.8	
666         .358         208.3         182         171         165         114         104         93         64         38         16         .512         470         .055         9.9           667         .292         208.3         149         139         135         93         85         76         52         31         14         .513         370         .043         10,1           668         .292         208.3         149         139         93         85         76         52         31         14         .513         370         .043         10,1           733         1.48         170.3         504         477         465         59         424         13         .509         27^n         .055         9.9           734         1.22         170.5         415         393         375         252         231         216         153         91         30         .519         1440         .239         63.0           734         1.01         170.5         273         312         210         192         181         128         76         25         .523         1200         .200         44         4 <td>665</td> <td></td> <td>. 428</td> <td>208.4</td> <td>217</td> <td>205</td> <td>198</td> <td>136</td> <td>124</td> <td>112</td> <td>46</td> <td>46</td> <td>17</td> <td>. 515</td> <td>580</td> <td>067</td> <td>13.9</td> <td></td>	665		. 428	208.4	217	205	198	136	124	112	46	46	17	. 515	580	067	13.9	
667         .292         208.3         149         139         135         93         85         76         52         31         14         .513         377         .043         10,1           668         .226         208.4         115         107         104         71         65         59         40         24         13         .509         270         .031         10,1           733         1.48         170.3         504         477         466         305         279         261         184         110         35         .518         1710         .285         59.2         734           734         1.22         170.5         415         393         375         252         231         216         153         91         30         .519         1440         .239         63.0           734         1.01         170.5         278         263         252         170         155         145         102         61         21         .523         1200         .200         44         4           735         .814         170.5         278         263         252         170         155         145         10	666		. 358	208.3	182	171	165	114	104	93	64	38	16	. 512	470	. 055	9.9	
668         .226         208.4         115         107         104         71         65         59         40         24         13         .509         27 <sup>n</sup> .031         10.1           733         1.48         170.3         504         477         465         305         279         261         184         110         35         .518         1710         .285         52.2           734         1.22         170.5         415         393         375         252         231         216         184         10         35         .519         1440         .239         66.0           734         1.01         170.5         415         393         375         252         231         216         184         10         35         .519         1440         .239         63.0           734         1.01         170.5         278         263         252         170         155         145         102         61         21         .522         1000         .166         29.1           735         .622         170.5         213         201         193         130         119         111         79         47	667		. 292	208.3	149	139	135	93	85	76	52	31	14	. 513	370	. 043	10.1	
133       1.49       170.5       170.5       309       471       409       305       279       201       164       110       55       518       1710       285       52.2         734       1.22       170.5       415       393       375       252       231       216       153       91       30       519       1440       239       63.0         734       1.01       170.5       415       393       375       252       231       216       153       91       30       519       1440       239       63.0         734       1.01       170.5       278       263       252       170       155       145       102       61       21       522       1000       .464       29.1         735       .814       170.5       278       263       252       170       155       145       102       61       21       .522       1000       .166       29.1         737       .622       170.5       213       201       193       130       119       111       79       47       17       .523       780       .132       17.8         738       .427	668		. 226	208.4	115	107	104	71	65	59	40	24	13	. 509	270	. 031	10.1	
734     1.22     170.5     415     393     370     222     231     216     133     91     30     .519     1449     .239     65.0       734     1.01     170.5     345     327     312     210     192     181     128     76     25     .523     1200     .200     44       735     .814     170.5     278     263     252     170     155     145     102     61     21     .522     1000     .166     29.1       737     .622     170.5     213     201     193     130     119     111     79     47     17     .523     790     .132     17.8       738     .427     170.3     146     138     132     89     81     76     54     32     14     .521     590     .099     9.4	733		1.48	170.3	504	477	456	305	279	261	184	110	35	. 518	1 710	. 285	92.2	
734       1.01       170.1       34) 32 / 312       210       192       181       123       76       25       .523       1200       .200       44       4         735       .814       170.5       278       263       252       170       155       145       102       61       21       .522       1000       .166       29.1         737       .622       170.5       213       201       193       130       119       111       79       47       17       .523       790       .132       17.8         738       .427       170.3       146       138       132       89       81       76       54       32       14       .521       590       .099       9.4	734		1.22	170.5	415	393	375	252	231	216	153	91	30	.519	1 440	. 239	63.0	
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$	734		1.01	170.1	345	327	312	170	192	181	128	76	25	. 523	1 200	. 200	44 4	
138         4         146         138         132         89         81         76         54         32         14         550         133         11.0 <t< td=""><td>130</td><td></td><td>622</td><td>170.5</td><td>212</td><td>203</td><td>199</td><td>130</td><td>110</td><td>111</td><td>70</td><td>47</td><td>17</td><td>. 522</td><td>790</td><td>. 100</td><td>17 8</td><td></td></t<>	130		622	170.5	212	203	199	130	110	111	70	47	17	. 522	790	. 100	17 8	
a not applicable.	738		. 427	170.3	146	138	132	89	81	76	54	32	14	. 521	590	. 099	9.4	†
	a Not ann	ı licable.													1			·

# TABLE V. - CONICAL NOZZLE DATA FOR NITROGEN

(a) Reduced temperature, 0.749

Reading	Reduced	Reduced	Stagnation	ļ		Pr	essu	re at	stati	on -	-1	1	Ratio of throat	Maximum mass flow	Reduced	Saturation	pressure,
1	ature.	sure.	ture.	1	2	3	4	5	6	7	8	9	stagnation	rate.	flow	"sat	, at -
	Т	P	To										pressure.	G	rate.	Stagnation	Stagnation
	r	r	-0										$P_{t}/P_{0}$	$\max^{-\max^{2}}$	G_	entropy	tempera-
								1						g/(cm )(sec)	r	s <sub>0</sub>	ture,
																	т
487	0.750	0.238	94.7	81	75	70	49	45	41	32	25	18	0.504	2 020	0.337	52.2	52.8
488	. 750	. 342	94.6	117	104	94	52	49	49	38	30	20	. 417	2 870	. 477	51.1	52.4
489	. 748	. 442	94.5	151	131	116	52	47	49	39	33	22	. 326	3 520	. 586	50.0	51.9
490	. 749	. 538	94.6	184	157	137	54	47	50	41	35	24	. 271	4 040	. 672	49.9	52.4
491	. 750	. 639	94.7	218	186	161	55	47		42	35	28	. 230	4 5 4 0	. 756	49.4	52.6
492	. 749	. 734	94.6	251	212	182	57	46			36	32	. 200	4 960	. 825	48.7	52.5
493		. 834		285	240	205	58	45	1			32	. 175	5 370	. 894	47.8	52.2
494		. 934		319	268	227	59		49			33	. 154	5 760	. 958	47.4	52.3
495		1.03		352	295	249	60					35	. 140	6 100	1.01	46.9	52.4
496		1.14		390	325	274	62					36	. 125	6 470	1.08	46.2	52.3
497		1.24		425	354	297	63						. 115	6 790	1.13	45.9	52.5
498		1.34		459	381	320	64		1				. 106	7 090	1.18	45.4	52.5
499		1.44		493	410	343	65		48				. 098	7 360	1.22	44.8	52.4
500	<b>1</b>	1.55		530	440	368	67	1	49				. 092	7 680	1.28	44.2	52.3
501	.750	1.65	94.8	564	469	392	1 70	44	48	۱.	1	17	. 085	7 950	1.32	44.2	53.0
502	.751	1.70	94.9	601	499	410	79	100	14	44	30	19	. 123	8 210	1.37	44.2	53.5
503	. 751	1.00	94.9	665	551	440	75	40	49	42	30	15	.078	8 410	1.41	43.0	53.4
504	. 751	1.95	94.0	005	331	400	1.0	1 44	40	42	30	15	.075	0 090	1.45	43.1	53.5
							()	o) Re	duced	i tem	pera	ture,	0.868				
505	0.862	0.636	108.8	217	196	180	108	96	87	61	44	36	0.400	3 450	0.574	131.6	137.1
506	. 863	. 836	109.0	286	255	231	128	119	116	84	61	44	. 408	4 190	. 698	128.5	138.3
507	. 864	1.04	109.1	354	310	276	130	117	121	92	68	50	. 340	5 000	. 833	125.2	139.1
508	. 865	1.24	109.2	424	366	322	132	114	120	94	70	55	. 284	5 710	. 950	122.2	139.9
509	. 865	1.44	109.2	491	422	367	135	112	120	95	73	60	. 244	6 340	1.05	119.1	140.1
510	. 865	1.65	109.3	565	483	418	137	109	119	96	74	63	. 211	6 950	1.16	116.1	140.7
511	. 866	1.86	109.4	635	539	465	140	108	119	96	75	66	. 187	7 480	1.24	113.6	141.3
512	.869	2.04	109.8	698	593	508	144	109	120	98	76	69	. 171	7890	1.31	113.8	145.1
513	. 870	1.75	109.9	598	511	441	142	112	123	99	76	66	. 205	7 160	1.19	114.5	145.9
514	. 867	1.75	109.5	599	511	441	140	110	120	97	75	64	. 201	7 220	1.20	116.2	142.8
515	. 868	1.55	109.6	530	454	395	138	113	121	97	74	62	. 228	6 640	1.10	120.1	143.6
516	. 869	1.37	109.7	468	403	353	137	116	123	97	73	58	. 263	6 100	1.02	123.9	144. 4
517	. 870	1.35	109.9	460	397	348	138	118	124	98	74	58	. 270	6 010	1.00	125.3	145.7
518	.869	1.15	109.8	393	341	303	130	120	125	96	10	53	. 318	5 370	. 893	128.6	145.1
213	. 870	. 943	109.9	322	200	201	130	144	120	91	50	20	. 301	2 720	. 101	133.3	145.7
520	.871	520	100.0	184	166	153	80	110 81	75	55	42	36	408	3 140	523	143 4	140.0
521	. 810		105.5	104	100	100			10	00	42	1.01	. 400	0 110	. 525	140.4	140.1
				_			(c	) Re	duced	tem	perat	ure,	0.942	÷ .			
739	0 942	2.66	119.0	908	781	679	226	170	182	144	105	88	0.201	8 480	1.41	168 3	238 6
740	942	2.44	119 0	833	718	626	221	173	184	145	104	85	. 221	8 000	1.33	173.0	238.6
741	. 941	2.23	118.9	763	659	577	217	174	184	144	102	83	.241	7 540	1.26	176.6	237.1
742	.945	2.04	119.3	697	606	534	217	181	189	146	102	78	.271	7 010	1.17	185.1	242.6
743	.942	1.80	119.0	614	537	477	212	182	188	142	98	72	. 306	6 410	1.07	188.8	238.3
744	.940	1.62	118.7	554	487	435	208	184	187	139	95	67	. 338	5 930	. 987	191.5	235.0
745	.943	1.44	119.1	492	436	395	211	191	191	136	92	61	. 388	5 310	. 883	201.9	240.4
746	. 942	1.35	119.0	460	411	373	209	192	187	131	91	58	. 407	5 000	. 833	204.1	238.9
747	.941	1.23	118.9	420	378	345	206	189	176	122	99	54	. 419	4 630	. 770	207.2	237.1
748	. 940	1.13	118.7	385	347	320	195	176	157	110	107	51	. 409	4 320	. 718	209.7	234.0
749	. 948	1.04	119.7	356	323	298	186	168	153	139	139	48	. 430	3 990	. 663	224.9	247.2
750	.948	. 934	119.7	319	292	273	182	170	161	153	153	43	. 504	3 550	. 591	231.3	247.5
751	. 946	. 837	119.5	286	266	252	185	177	171	162	159	38	. 597	3 050	. 507	235.5	245.3
752	. 944	. 731	119.2	250	236	228	184	178	174	168	153	31	. 696	2 380	.396	239.1	241.7
			1		1		- I	- 1	- 1			1 1	1		1	1	1

#### TABLE V. ~ Concluded.

Reading	Reduced	Reduced	Stagnation	I		Pre	ssur	e at :	static	n -		1	Ratio of throat	Maximum	Reduced	Saturation	pressure,
	temper-	pres-	tempera-	. 1			.	-					pressure to	mass flow	mass	Psat	, at -
	ature,	sure,	ture,	1	2	3	4	э	ь	1	8	9	stagnation	rate,	flow	a	<b>6</b> 4
	Tr	Pr	To										pressure,	G <sub>max</sub> ,	rate,	Stagnation	Stagnation
	-	-	Ű										$P_t/P_0$	$g/(cm^2)(sec)$	G <sub>r</sub>	entropy,	tempera-
														8, (, /(,	_	<sup>5</sup> 0	ture,
																-	<sup>T</sup> 0
527	1.029	1.14	130.0	391	376	364	274	256	242	179	116	32	0.619	1 830	0.304	336.3	(a)
528	1.025	. 930	129.6	318	302	290	213	202	202	145	92	22	. 637	1 350	. 224	235.4	
529	1.031	.830	130.2	284	270	258	175	160	151	125	81	20	. 531	1 170	. 195	181.6	
530	1.030	.740	130.1	253	240	230	156	142	134	101	69	19	. 528	1 010	. 169	144.3	
531	1.027	. 633	129.8	216	205	197	133	122	114	80	56	16	. 529	850	. 141	105.3	
532	1 028	536	129.8	183	173	167	112	103	96	68	40	15	. 526	710	. 119	74.5	
533	1 028	438	120.0	150	142	136	92	84	79	56	33	14	526	580	. 096	50.6	
769	1.025	2 07	129.5	709	634	573	298	265	268	230	221	75	379	5 900	982	278.5	
770	1.024	1 96	120.0	660	601	546	208	269	270	230	226	72	404	5 590	.930	282 5	
771	1.021	1.00	120.4	632	572	523	302	275	275	250	230	68	435	5 220	868	289.8	
1 779	1 025	1.00	120.5	502	544	501	303	270	279	250	230	65	465	4 880	812	294.2	
779	1.025	1.10	129.5	561	514	476	207	210	204	200	230	61	507	4 490	746	301.2	
774	1.020	1.04	129.5	501	100	410	210	201	204	200	220	57	550	4 120	696	206 7	
776	1.025	1.55	129.5	402	409	407	217	200	291	210	217	51	616	3 630	604	314 0	
776	1.025	1.94	129.4	452	409	400	211	216	303	200	170	10	.010	3 060	500	314.5	
700	1.025	1.04	129.0	409	400	414	320	004	310	016	140	40	. 052	2 5 1 0	417	324.0 222 A	
	1.024	1.20	129.4	420	407	393	322	204	214	210	140	30	. 044	2 510	. 410	000 5	
118	1.025	1.20	129.4	420	407	393	322	284	215	210	148	39	. 645	2 520	.419	333.5	
779	1.024	1.15	129.4	392	376	365	275	257	243	180	114	33	. 620	1 590	. 314	340.5	
780	1.025	1.05	129.5	357	341	330	245	227	215	158	102	26	. 602	1 520	. 254	300.1	
782	1.024	.948	129.3	324	307	295	221	211	209	145	93	23	. 645	1 340	. 223	248.1	
783	1.025	. 848	129.4	290	274	262	181	100	128	129	83	21	. 548	1 190	. 197	197.3	
784		. 751	129.5	257	243	233	159	144	135	106	69	19	. 524	1 010	. 168	153.3	
-785		. 607	129.5	207	196	188	128	116	109	76	52	16	. 524	800	. 134	97.8	1
786		. 386	129.4	132	124	119	81	74	69	48	28	13	. 522	500	. 084	40.8	
787		. 401	129.5	137	128	124	84	76	71	50	29	14	. 521	530	. 088	43.7	
							(6	e) Re	duced	l tem	pera	ture,	1.10				
			1	''					· · · ·				[				
755	1.10	2.66	139.4	910	823	751	387	334	322	297	267	84	0.354	6140	1.02	323.5	(a)
756		2.44	139.4	833	758	697	384	339	328	304	265	78	. 394	5 5 5 0	. 923	329.5	
757		2.24	139.3	764	700	649	382	343	333	310	259	72	. 435	4 980	. 828	334.5	
758		2.04	139.4	696	643	601	379	348	337	312	244	65	. 485	4 350	. 724	339.0	
759		1.82		621	580	548	371	347	340	308	222	56	. 548	3 590	. 597	341.1	
760		1.65		562	529	504	356	337	333	294	200	48	. 593	2 980	. 496	337.7	
761		1.54	l T	527	498	475	340	322	320	273	178	42	. 608	2 620	. 436	329.2	
762		1.44	139.3	492	465	445	315	297	294	246	159	38	. 598	2 300	. 383	312.0	
763		1.21	139.2	415	392	375	253	233	219	188	123	29	. 529	1 820	. 302	242.5	
764		1.00	139.1	343	325	311	211	193	181	128	92	25	. 526	1 400	. 233	169.3	
765		. 839	139.4	287	271	260	176	161	151	107	71	21	. 527	1 1 4 0	. 190	115.5	
766		. 711	139.3	243	230	221	150	137	128	91	54	18	. 526	970	. 161	82.1	
767		. 537	139.2	184	174	167	113	103	96	68	40	15	. 524	760	. 126	47.9	
768	¥	. 385	139.2	131	124	120	81	74	69	49	28	13	. 524	590	. 097	25.7	

# (d) Reduced temperature, 1.025

<sup>a</sup>Not applicable.

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#### TABLE VI. - ELLIPTICAL NOZZLE DATA FOR OXYGEN

#### (a) Reduced temperature, 0.611

Reading	Reduced	Reduced	Stagnation			Pr	essui	•e at	stati	on -			Ratio of throat	Maximum	Reduced	Saturation	pressure,
	ature,	pres- sure, P <sub>r</sub>	tempera- ture, T <sub>0</sub>	1	2	3	4	5	6	7	8	9	stagnation pressure,	mass flow rate, G <sub>max</sub> ,	flow rate,	P <sub>sat</sub> Stagnation	, at - Stagnation
		-											P <sub>t</sub> /P <sub>0</sub>	g/(cm <sup>2</sup> )(sec)	G <sub>r</sub>	entropy, <sup>S</sup> 0	tempera- ture, T <sub>0</sub>
63	0. 633	0. 427	97.9	217	206	71	26	19	17	11	9	10	0.086	6 090	0.702	20.5	21.3
64	. 615	. 431	92.2	219	207	68	22	15	14	10	12	15	. 069	6 210	.716	16.1	16.7
65	. 611	. 564	94.6	287	273	86	26	15	14	9	5	5	. 051	7 190	. 829	15.0	15.7
66	.611	.565	94.5	287	273	87	26	15	14		9	12	. 051	7 180	. 828	14.9	15.6
68	.008	834	94.2	300	339	107	29		13		<sup>3</sup>	5	.040	8 060	. 929	14.2	15.1
69	. 605	. 969	93.7	492	470	143	37		1 <sup>1</sup>				. 029	9 530	1.10	13.0	14.7
70	.604	1.10	93.4	561	537	167	41			8			. 025	10 200	1, 18	12.7	14 1
71	. 602	1.24	93.2	630	603	188	43			1 i			. 022	10 850	1.25		13.7
72	. 600	1.38	92.9	700	670	208	48						. 020	11 480	1.32		13.4
73	. 601	1.31	93.1	665	636	198	46						. 021	11 170	1.29		13.6
74	. 603	1.17	93.4	596	569	174	42						. 024	10 550	1.22	12.6	14.0
75	. 605	1.04	93.6	528	504	159	39		1			🕴	. 027	9 880	1.14	13.0	14.3
76	. 607	.901	93.9	458	437	137	35		13	9		5	. 031	9 190	1.06	13.6	14.8
77	. 608	.767	94.2	390	371	115	32	15	13			5	. 037	8 460	. 975	14.1	15.1
78	. 611	. 631	94.5	321	305	97	27		14		1	5	. 045	7 640	.881	14.8	15.6
79 00	. 612	. 495	94.8	251	238	78	24				6	6	. 058	6 710	.774	15.3	16.0
0U 91	. 615	. 308	95.2	182	113	58	10					8	. 083	5 660	.653	16.1	16.6
82	618	. 290	95.5	113	107	40	19				0	10	. 099	4 350	502	10.0	16.9
83	. 620	. 156	96.0	79	74	32	18		14		10	11	. 190	3 460	399	17.7	17.8
84	. 624	. 088	96.6	45	41	24	17		12	10	10	10	. 338	2 260	. 261	18.8	18.9
218	0.625	1.17	96.7	596	569	178	45	18	15	10	7	5	0.030	10 470	1.21	17.1	19.2
219	. 624	1.31	96.5	667	638	199	52		15				. 027	11 100	1.28	16.6	18.8
220	. 622	1.44	96.3	733	701	216	54		14				. 025	11 690	1.35	16.0	18.4
221	. 620	1.58	96.0	802	768	232	59			🕴			. 023	12 240	1.41		17.9
222	. 619	1.71	95.8	871	834	251	63			9			. 021	12 780	1.47		17.6
223	. 617	1.85	95.6	942	902	270	67			9			. 019	13 330	1.54		17.2
224	. 618	1.78	95.7	907	869	258	65			9			. 019	13 070	1.51		17.4
226	621	1.51	95.9	768	735	291	56	ĺ					. 022	12 340	1.40	15 7	17.7
227	. 622	1.38	96.3	701	670	204	53				7		. 024	11 460	1.32	16.2	18.5
228	. 624	1.25	96.5	633	605	189	50		15				. 029	10 810	1.25	16.7	18.8
229	. 625	1.10	96.8	558	534	170	44		15				. 032	10 180	1.17	17.3	19.3
230	. 627	.972	97.0	494	471	150	41		16	11		•	. 037	9 5 4 0	1.10	17.9	19.6
231	. 628	.835	97.3	425	404	128	38					6	. 043	8 790	1.01	18.5	20.1
232	. 630	. 703	97.5	357	340	110	36	¥			♥ .	6	. 051	8 040	. 927	19.2	20.5
233	. 632	. 563	97.8	286	273	88	31	19	🕴		8	7	. 065	7 160	. 826	20.0	21.0
234	. 634	. 427	98.1	217	207	70	28		17		9	10	. 086	6 160	.710	20.7	21.6
235	. 636	. 293	98.4	149	142	55	25				11	12	. 125	4 980	. 575	21.7	22.2
230	. 637	225	90.0	114	100	49	20	1		10	11 19	12	. 140	4 040	. 535	22.0	22.5
238	. 638	. 190	98.8	97	92	40	24	20	16	11	12	12	203	3 870	494	22.3	22.1
239	. 639	. 156	98.9	79	76	35	23	20	17	11		12	.248	3 410	. 393	22.9	23.9
	. 641	. 123	99.2	63	59	31	23	20	15	10		11	. 314	2 880	. 332	23.6	23.8
240		1				1				- E	1						•
240 241	. 643	.090	99.5	46	43	27	22	19	13		11	11	. 409	2 270	.262 1	24.3	24.5
240 241 242	. 643 . 645	.090 .071	99.5 99.8	46 36	43 35	27 24	22 20	19 18	13 13		11 11	11 11	. 409 . 486	2 270 1 890	. 262	24.3 25.0	24.5 25.1
240 241 242 243	. 643 . 645 . 648	.090 .071 .057	99.5 99.8 100.3	46 36 29	43 35 27	27 24 21	22 20 19	19 18 16	13 13 13		11 11 10	11 11 10	. 409 . 486 . 554	2 270 1 890 1 540	. 262 . 218 . 177	24.3 25.0 26.0	24.5 25.1 26.1

#### (c) Reduced temperature, 0.749

Reading	Reduced	Reduced	Stagnation			$\Pr{\epsilon}$	ssure	e at s	statio	n -			Ratio of throat	Maximum	Reduced	Saturation	pressure,
	temper-	pres-	tempera-	1		2		5	6	7	8	0	pressure to	mass flow	mass	P <sub>sat</sub> ,	at -
	ature,	sure,	ture,	1	4	3	7			•	Ů	1	stagnation	rate,	flow	Staunation	Stagnation
	Tr	<sup>p</sup> r	T <sub>0</sub>										pressure,	G <sub>max</sub> ,	rate,	entrony	tempera-
								!					$P_t/P_0$	$g/(cm^2)(sec)$	G <sub>r</sub>	S.	ture.
				1						1						~0	T <sub>o</sub>
												ĺ					-0
85	0.746	0.427	115.5	217	208	109	76	67	40	22	20	22	0.308	5 030	0.580	75.3	77.9
86	. 751	. 428	116.3	217	209	111	78	69	40	22	20	22	. 317	5 010	. 577	79.1	81.8
88	. 750	. 697	116.1	354	340	147	84	68	46	25	21	24	. 191	7 000	. 807	75.6	80.8
89	. 749	. 831	116.0	423	406	169	84	67	46	25	20	24	. 158	7 820	. 901	74.0	80.3
90	. 748	. 973	115.9	494	475	188	87	66	47	26	18	24	. 134	8 570	. 988	72.1	79.7
91	. 748	1.10	115.8	561	539	206	90	65	47		17	22	. 116	9 2 4 0	1.07	70.7	79.3
92	.747	1.24	115.6	631	607	220	92	65	48		16	21	. 103	9 900	1.14	69.0	78.6
93	. 747	1.38	115.6	700	673	244	99	64	47		16	19	. 092	10 480	1.21	67.7	78.2
94	. 746	1.44	115.5	732	704	253	100	64			15	19	. 087	10 750	1.24	67.1	78.1
95	.747	1.31	115.7	666	640	232	95	65			15	20	. 097	10 200	1.18	68.8	79.0
96	.748	1.17	115.9	597	573	212	94	65	1		17	22	. 109	9 570	1.10	70.5	79.7
97	. 750	1.04	110.1	528	507	197	93	67	40		10	23	. 120	8 910	1.03	72.5	80.7
98	1.751	.902	110.2	458	974	150	01	60	41	25	19	24	. 147	8 190	.944	74.0	81.6
100	. 752	620	116.4	390	307	141	84	70	40	20	21	24	220	6 5 3 0	.000	78.8	82.0
100	755	.029	116.0	252	242	122	83	72	40	20	22	23	285	5 560	640	81.2	84.6
102	756	358	117 1	182	175	105	78	69	36	21	18	21	381	4 3 0 0	496	83.9	85.9
102	757	. 293	117.2	149	143	93	67	60	32	20	17	20	400	3 680	. 425	85.4	86.7
104	. 759	.224	117.5	114	109	75	52	47	30	20	16	18	. 414	3 090	. 356	87.3	87.9
210	. 754	1.17	116.8	596	572	216	100	68	49	27	18	23	. 115	9 470	1.09	74.6	84.2
211	. 756	1.31	117.1	667	641	236	98	69	49	27	18	22	.104	10 100	1.16	74.7	85.8
212	. 756	1.44	117.1	734	705	258	103		50	27	17	21	. 094	10 650	1.23	73.8	85.9
213	. 757	1.58	117.1	804	773	276	112		50	28		19	. 086	11 200	1.29	72.9	86.2
214	. 757	1.72	117.2	872	839	294	111		50	28		18	. 079	11 720	1.35	72.2	86.7
215	. 759	1.85	117.5	941	905	309	114	70	52	28	🕴	16	. 075	12 220	1.41	72.3	88.1
216	. 765	1.92	118.4	975	938	328	123	73	54	29	18	16	. 075	12 390	1.43	75.9	93.1
217	. 768	1.79	118.9	908	872	309	119	76	54	29	18	20	. 083	11 870	1.37	79.1	95.8
249	. 743	1.17	115.0	596	572	208	86	62	45	25	17	21	. 103	9 680	1.12	66.8	75.5
250	. 745	1.17	115.4	596	571	210	94	64	46	25	17	22	. 107	9 510	1.10	68.5	77.4
251	.745	1.31	115.3	663	637	228	96	62	45	26	16	21	. 094	10 210	1.18	67.0	76.8
252	.744	1.44	115.2	734	705	250	98		46		17	19	.085	10 770	1.24	65.9	76.7
253	.744	1.58	115.1	802	171	271	100			ļ	16	10	.071	11 350	1.31	69.4	76.1
255	743	1.12	114.9	0/2	905	200	111			25		13	065	12 370	1 42	62.0	76.0
256	.743	1.92	115 1	976	938	315	106		47	26		12	, 063	12 640	1.46	61.9	75.8
257	.745	1.78	115.3	906	870	300	111		46	Ī		14	. 069	12 090	1.39	63.6	76.8
258	. 746	1.65	115.4	837	804	277	102	63	47			15	. 075	11 600	1.34	65.3	77.6
259	. 747	1.51	115.7	766	736	262	104	64	47			18	. 083	11 040	1.27	67.2	78.7
260	. 748	1.39	115.8	705	676	243	100	64	47		17	20	. 091	10 520	1.21	68.8	79.6
261	. 750	1.24	116.0	631	606	223	91	65	48		18	22	. 102	9 880	1.14	70.7	80.6
262	. 751	1.11	116.2	563	539	206	95	66	47		19	23	. 117	9 2 4 0	1.06	72.7	81.4
392	. 757	. 899	115.6	457	438	172	86	64	45	25	20	24	. 141	8 280	. 954	71.6	78.5
393	. 748	. 768	115.7	390	374	155	84	65	45	25	22	24	. 167	7 530	. 868	73.4	79.1
394	. 749	. 632	115.9	321	308	138	81	66	43	24	23	25	. 206	6 650	. 766	75.3	79.8
395	. 749	. 562	116.0	285	275	127	81	67	43	24	23	24	. 234	6 160	. 710	76.3	80.2
396	. 749	. 496	116.0	252	242	120	79	68	41	23	22	24	. 271	5 630	. 649	77.0	80.3
397	. 750	. 425	116.1	216	208	110	79	68	39	20	21	23	. 316	5 040	.581	78.2	80.8
398	. 750	. 359	116.1	183	176	101	77	67	36	21	20	21	. 368	4 410	. 509	79.0	81.1
399	. 751	. 290	116.3	147	142	91	68	59	31	20	18	20	. 400	3 680	. 424	80.5	81.7
400	.752	. 225	116.4	114	111		57	49	29	20		18	. 430	3 010	. 347	81.5	82.6
401	. 153	. 170	116.6	86	83	02	48	42	28	21	10	10	. 480	2 420	. 279	03.0	03.0

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## (d) Reduced temperature, 0.810

·	1	1	1	I.										I		,	
Reading	Reduced	Reduced	Stagnation	n		Pr	essu	re at	stati	on -			Ratio of throat	Maximum	Reduced	Saturation	pressure.
	temper-	pres-	tempera-			1.		Ι.	1.	1 -	Ι.	1	pressure to	mass flow	mass	Part	, at -
	ature,	sure,	ture,	1	2	3	4	5	6	7	8	9	stagnation	rate,	flow,	sat	
	Tr	P <sub>r</sub>	Т							1			pressure,	G	rate.	Stagnation	Stagnation
			ľ	ļ		1	1						$P_t/P_0$	max'	G	entropy,	tempera-
1			1		1									g/(cm )(sec)	r	s <sub>0</sub>	ture,
														1		, u	Т
150	0.800	0 427	199 0	017	1010	1.01				0.5							
151	802	565	123.0	211	210	150	116	102	41	20		20	0.368	4 530	0.522	123.6	126.8
152	803	606	124.2	201	2/1	170	110	102	49	120	23	29	. 357	5 450	. 628	123.7	129.4
154	805	067	124.4	401	170	214	123	109	1 50	29	24	30	.309	6 360	.733	122.6	130.5
155	805	1 11	124.0	491	-413 E 49	214	130	109	03	32	20	33	. 221	7 940	.915	120.1	132.4
156	906	1.11	124.7	002	042	234	132	107	64	33	23	33	. 190	8 650	. 997	118.2	132.5
157	806	1.20	124.7	200	674	209	130	105	60	34	22	32	. 166	9 3 4 0	1.08	116.4	133.2
158	807	1.30	124.0	741	714	214	120	105	67		21	32	. 149	9 900	1.14	115.2	133.7
150		1.20	124.5	141	640	200	139	105	01		21	31	. 142	10 220	1.18	114.5	134.2
109	. 808	1.31	125.0	007	043	265	139	107	67		21	32	. 160	9 600	1.11	117.4	135.3
160	. 809	1.18	125.2	598	576	246	137	109	66	*	23	33	. 182	8 950	1.03	120.8	136.8
161	.810	1.04	125.4	528	508	228	135	111	65	33	24	33	. 211	8 270	. 953	123.7	137.7
162	. 810	. 908	125.4	461	444	211	134	114	63	32	25	33	. 247	7 550	. 870	125.9	137.9
163	. 811	. 769	125.5	391	377	195	132	115	60	32	24	32	. 294	6 720	. 774	129.0	138.6
164	.811	. 629	125.6	320	309	177	127	111	53	29	23	30	. 346	5 770	. 665	132.0	139.2
165	. 811	. 494	125.6	251	243	149	102	90	45	27	22	28	. 359	4 890	. 564	135.0	139.5
166	.812	. 422	125.7	215	208	131	91	80	43	27	21	26	. 371	4 440	.512	136.5	139.9
167	. 813	. 357	125.8	182	175	111	72	64	38	26	22	25	. 354	4 070	. 469	139.4	141.2
168	. 814	. 292	125.9	149	143	101	75	66	41	30	19	21	. 446	3 360	. 387	141.7	142.0
291	. 806	1.17	124.8	595	573	244	135	105	65	34	24	33	. 176	8 860	1.02	118.2	133.9
292	. 807	1.31	124.9	667	642	267	137	105	65	34	22	32	. 157	9 510	1.10	116.8	134.6
293	. 807	1.45	124.9	734	707	284	141	103	66	34		31	. 141	10 110	1.17	114.9	134.4
294	. 807	1.58	124.9	805	775	305	143	102	67	35		30	. 127	10 660	1.23	113.0	134.4
295	.806	1.71	124.8	871	839	323	144	102	67			29	. 117	11 160	1.29	110.8	133.9
296	.807	1.85	124.9	938	903	339	150	101	67			27	. 108	11 680	1.35	109.5	134.2
297	. 808	1.93	125.1	979	943	352	157	102	68	Í	+	26	. 105	11 930	1.37	109.7	135.7
298	. 809	1.85	125.2	940	904	344	150	103	68		21	28	. 110	11 660	1.34	111.6	136.8
299	.810	1.79	125.3	908	873	329	147	105	68		22	28	. 115	11 410	1.32	112.9	137.5
300	. 811	1.65	125.5	838	806	311	148	106	68		22	30	. 127	10 850	1.25	115.6	138.6
301	.811	1.52	125.6	771	742	298	148	107	68		22	32	. 139	10 310	1.19	118.0	139.3
302	. 812	1.38	125.7	700	673	275	143	110	68		23	33	. 157	9 710	1.12	121.0	140.5
303	. 813	1.24	125.9	632	608	259	141	111	68	*	24	33	. 175	9 130	1.05	123.7	141.4
304	. 814	1.11	126.0	563	541	239	143	114	66	34	25	34	. 202	8 440	. 973	126.8	142.3
305	. 815	. 975	126.1	495	477	222	140	116	65	33	26	33	. 235	7 730	. 891	129.6	143.1
306	. 815	. 837	126.2	425	410	204	138	119	62	32	26	33	. 280	6 950	. 801	132.7	143.8
307	. 816	. 700	126.3	356	344	187	135	117	57	30	25	31	. 330	6 040	. 696	135.8	144.4
308	. 816	.570	126.4	290	281	168	123	105	48	27	24	29	. 363	5 140	. 593	139.0	145.2
309	. 817	. 497	126.4	252	245	157	105	90	46	28	23	28	. 357	4 710	. 543	140.9	145.6
310	. 817	. 427	126.5	217	211	134	93	81	45	28	23	26	. 372	4 270	. 492	142.8	145.9
311	. 818	. 392	126.6	199	193	120	79	68	40	28	23	26	. 343	4 110	. 474	144.5	146.9
312	. 819	. 327	126.8	166	161	106	75	64	38	27	22	24	. 386	3 550	. 409	147.4	148.3
313	. 819	. 292	126.8	148	145	114	92	82	56	40	16	16	. 551	2 750	. 317	147.8	148.8
I	1	1				l	l	- 1		ļ			l				ļ

							1-	) Pr	hiced	tem	erat	ure	0.854				
	1	1	l	1		_	(6	.) nec	iucea	te mj	erat	ure,	0.004		1	1	
(eading	Reduced	Reduced	Stagnation	1		Pre	ssur.	e at s	statio	n -			Ratio of throat	Maximum	Reduced	Saturation	pressure
	temper-	pres-	tempera-	1	2	3	4	5	6	7	8	9	pressure to	mass flow	mass	Psat'	at -
	ature,	sure,	ure,										stagnation	rate,	now	Stagnation	Stagnatic
	<sup>1</sup> r	Pr	10					l l					pressure,	Gmax'	rate,	entropy.	tempera
											f		Pt/P0	g/(cm <sup>2</sup> )(sec)	Gr	S	ture.
																	Т
					í I												
111	0.851	0.427	131.8	217	210	135	93	82	47	32	24	28	0.380	4 070	0.469	188.9	190.6
112	. 853	. 561	132.0	285	276	163	99	87	47	31	26	33	. 307	5 030	. 579	187.3	193.2
113	.854	. 697	132.3	354	344	203	135	119	56	33	25	34	. 336	5 660	. 653	185.1	195.3
114	. 856	. 834	132.4	424	411	237	170	147	65	35		36	. 348	6 290	. 726	182.7	197.0
115	. 856	. 969	132.6	492	477	256	180	158	72	36		37	. 320	7 070	. 816	180.1	198.2
116	. 857	1.11	132.7	563	545	276	184	161	77	38		39	. 286	7 810	. 900	177.5	199.4
117	. 858	1.24	132.8	632	612	295	187	160	80	39		39	. 253	8 490	. 979	174.8	200.1
118	. 858	1.38	132.8	702	680	312	189	158	82	40		40	. 225	9 120	1.05	172.0	200.8
119	. 858	1.44	132.9	734	710	325	190	157	83	41		40	. 214	9 400	1.08	171.0	201.3
120	. 859	1.31		666	644	307	189	159	81	40		40	. 239	8 780	1.01	174.6	201.8
121	. 859	1.17		596	577	285	187	161	79	38		39	. 512	8 130	. 938	178.0	201.8
122	. 859	1.04		529	512	268	184	161	76	38		38	. 305	7 430	. 856	181.3	201.6
123	. 858	. 901		458	444	248	178	155	69	36		37	. 339	6 660	. 768	184.9	201.3
124		.768		391	379	226	158	136	59	33		35	. 348	5 920	682	188.8	201.3
125	1 1	. 630	132.8	320	310	186	122	109	54	33	26	33	. 339	5 300	612	192.2	200.3
126		. 495	132.8	251	244	148	94	83	46	31	25	31	. 329	4 580	. 528	196.6	200.1
110	. 848	. 900	131.3	457	443	23R	170	147	68	35	Ĩ	36	, 322	6 870	. 792	170.6	186
411	. 848	.766	131.2	389	378	221	158	136	60	33		34	349	6 060	600	173.9	185 9
412	.847	. 635	131.1	323	313	186	124	108	53	32	I I	33	. 333	5 430	626	176.2	184 4
413	. 846	. 563	131.0	286	278	168	110	96	50	32	26	32	. 336	5.040	581	177 B	184
414	.846	. 496	130.9	252	244	146		79	44	31	26	31	. 312	4 720	544	178.6	182 9
415	.845	458	130.8	233	226	137	87	77	42	30	26	30	329	4 490	517	178.8	181 0
416	.844	. 497	130 7	217	211	132	80	78	45	31	25	28	360	4 200	494	179 0	181 9
417	.844	387	130 7	197	191	126	01	70	46	32	24	26	403	3,810	430	180.3	181 9
418	.844	. 363	130.7	185	180	125	94	82	50	36	23	23	. 446	3 510	. 405	180.4	180 6
132	0.877	0.560	135.7	284	276	167	106	94	51	35	27	33	0.331	4 800	0.554	224.7	230.1
133	.880	. 697	136.2	354	343	202	122	108	56	36	28	36	. 304	5 550	. 639	224.4	235.5
134	. 882	.840	136.5	427	414	246	162	140	63	36	27	38	. 329	6 090	, 702	222.0	238.7
135	. 884	.971	136.8	493	480	278	198	170	71	38	26	39	. 345	6 630	. 765	219.7	241.5
136	. 885	1.11	137.0	563	548	299	212	186	79	39	27	40	. 330	7 3 4 0	.847	216.8	243.7
137	. 886	1.25	137.1	634	615	321	218	191	84	41	27	42	. 301	8 040	. 927	213.6	245.1
138	. 887	1.38	137.3	700	680	341	222	191	90	42	27	43	. 274	8 620	. 994	211.2	247.1
139		1.46	137.3	744	722	353	223	192	91	44	28	43	. 258	9 000	1.04	209.1	247.6
140		1.31	137.3	666	646	332	221	193	87	42	27	42	, 290	8 320	. 959	213.4	247.4
141		1.18	137.3	599	581	312	217	190	83	41	27	41	317	7 660	. 884	217.1	246 5
142	.886	1.03	137.2	524	510	289	206	178	75	38	26	40	.340	6 920	. 797	221.4	246 0
143	. 886	,910	137.1	462	449	266	183	156	66	37	27	38	, 338	6 330	729	224.9	244.5
144	. 885	. 771	137.0	392	380	224	143	127	62	37	27	37	. 323	5 810	. 670	229.7	244 9
145	.884	. 631	136 7	321	311	184	111	99	52	35	29	35	308	5 170	. 596	234 2	242 3
146	. 883	.500	136 7	254	247	162	115	101	57	38	26	20	399	4 200	484	238 8	240 5
263	. 879	1.91	136 1	971	930	404	218	170	92	44	28	41	175	10 960	1.26	186.2	230.1
264		1 78	100.1	904	872	384	218	172	91	43	1	42	191	10 430	1 20	189.8	230.0
265		1 79		872	843	382	217	174	90	10		42	199	10 200	1 19	191.2	234.9
266		1 65		828	810	372	217	175	80	11		42	200	9 0200	1 14	193 1	201.1
267	880	1.05	136.2	0.00	915	306	210	171	0.9			41 1	180	10 750	1 24	189 4	234.4
268	.000	1.00	136.0	802	776	361	223	102	80	l	I I	42	297	9 550	1 10	201 2	200.2
260	.004 894	1.50	130.9	766	740	357	220	196	80	12	20	10	249	9 3 3 0	1.10	201.3	542.3 945 -
270	997	1.51	197.9	100	700	331	222	190	09	44	29		256	8 020	1.00	200.0	240.
271	1001	1 20	197 9	700	670	349	222	100	00 97	44	20		. 200	8 660	077	200.0	240.0
272		1.38	131.2	100	078	334	221	100	07 9=	42			. 210	9 220	.977	210.8	246.5
272		1.31	107.0	000	640	327	220	100	00	41	l l i	1	. 200	8 000	. 909	215.0	247.1
274	¥	1.29	131.2	029 507	609	319	219	190	04	41	1	42	. 302	7 650	. 923	213.0	240.5
274 275	.007	1.18		597	579	309	217	104	80	40	28	42	. 315	7 200	. 882	217.0	246.5
276	.000	1.10		500	543	298	213	104	18	39	40 97	11	. 368	6 060	. 041	219.2	240.2
410		1.04		528	012	286	207	107	13	38	27	40	. 330	0 960	.803	221.1	240.0
977 I		. 965		490	416	211	182	100	10	38	27	39	. 337	0 580	. 759	223.6	245.7
277		. 902	105	458	445	263	179	152	06	37	28	39	. 332	6 300	. 726	226.1	245.7
277 278 270		.834	137.1	424	411	242	159	137	64	38	28	38	. 322	5 070	.700	228.2	245.1
277 278 279			131.0	390	318	221	142	124	10	37	29	31	. 318	5 550	620	230.1	244.3
277 278 279 280 281	. 885	. 107 goo	137 0	222	244	100	110	100									
277 278 279 280 281	. 885	. 698	137.0	355	344	199	118	103	24	37	29	37	. 292	5 100	. 033	233.1	0.00
277 278 279 280 281 282	.885 .885 .885	. 698	137.0 137.0	355 321	344 312	199 184	118 112	103 98	52	37	29 29	37	. 306	5 180	. 591	235.6	243.0
277 278 279 280 281 282 283	. 885 . 885 . 885 . 885 . 884	. 698 . 632 . 564	137.0 137.0 136.9	355 321 286	344 312 278	199 184 169	118 112 113	103 98 98	54 52 53	37 36 36	29 29 28	37 36 33	. 306 . 343	5 180 4 730	. 591	235.6	243.0
277 278 279 280 281 282 283 283 284	. 885 . 885 . 885 . 884 . 884	. 698 . 632 . 564 . 495	137.0 137.0 136.9 273.6	355 321 286 251	344 312 278 245	199 184 169 163	118 112 113 118	103 98 98 103	52 53 58	37 36 36 40	29 29 28 28	37 36 33 28	. 306 . 343 . 412	5 180 4 730 4 110	. 591 . 545 . 473	235.1 235.6 237.7 240.5	244.3 243.0 242.6 242.1

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#### (g) Reduced temperature, 0.952

Reading	Reduced	Reduced	Stagnation			Pr	essur	e at	stati	on -			Ratio of throat	Maximum	Reduced	Saturation	pressure,
	temper-	pres-	tempera-	-		Ta	TT.	1 -	1.	1 -			pressure to	mass flow	mass	Psat	, at -
	ature,	sure,	ture,	1	2	3	4	10	0	1	8	9	stagnation	rate,	flow		
ŀ	т <sub>г</sub>	P <sub>r</sub>	T <sub>0</sub>							1			pressure,	G <sub>max</sub> ,	rate,	Stagnation	Stagnation
	-		_	}	}								$P_t/P_0$	$g/(cm^2)(sec)$	Gr	entropy,	tempera-
																<sup>5</sup> 0	ture,
																	T <sub>0</sub>
173	0.908	0.560	140.6	285	282	249	208	189	99	35	8	14	0.664	2 960	0.341	278.9	285.7
174	. 927	. 708	143.5	360	352	230	180	171	169	111	23	23	. 476	5 1 4 0	. 592	316.7	323.2
175	. 932	. 832	144.2	423	413	254	181	171	169	121	27	24	. 404	5 800	. 669	317.5	333.6
176	. 936	. 965	144.8	490	478	285	188	171	165	125	31	26	. 348	6 390	. 737	315.9	342.5
177	. 939	1.10	145.4	559	545	323	212	183	158	127	32	26	. 328	6 860	. 790	313.8	350.5
178	. 943	1.24	145.9	631	617	364	249	211	153	126	34	27	. 334	7 270	. 838	311.2	358.2
179	.946	1.38	146.5	701	685	395	279	239	147	127	36	28	. 341	7 750	. 893	309.3	366.1
180	. 949	1.45	146.9	735	717	413	291	250	150	129	37	28	. 341	7 970	.918	310.5	372.2
181	.948	1.32	146.8	670	654	384	267	228	164	128	35	27	. 340	7 480	. 862	317.3	371.1
182	.946	1.17	146.5	595	581	348	235	202	177	126	33	26	.340	6 980	. 804	323.3	366.5
183	.944	1.02	146.1	520	508	312	219	200	191	121	30	25	. 385	6 400	.738	329.5	361.2
184	. 943	. 905	146.0	460	449	294	227	215	207	110	25	23	. 467	5 730	. 660	338.3	359.7
185	.941	.775	145.7	394	387	278	239	231	220	88	20	20	. 588	4 850	. 559	345.3	354.2
186	. 943	. 791	146.0	402	395	286	246	237	224	88	20	20	. 591	4 850	. 559	349.1	359.0
187	. 948	. 820	146.7	417	410	305	266	257	231	83	19	18	. 615	4 800	. 553	358.1	369.9
188	. 962	1.10	148.9	557	546	366	285	264	242	109	27	22	. 475	6 060	. 698	363.4	403.5
189	.983	1.39	152.2	709	695	445	337	304	262	120	31	23	. 429	6 950	801	384.7	460.1
348	.945	1.18	146.3	597	581	341	228	196	173	128	34	27	. 328	6 810	785	320.6	363 8
349	.947	1.31	146.6	664	647	377	258	219	162	129	36	28	. 329	7 220	.832	316.1	368.8
350	949	1 44	146.9	733	714	403	285	244	153	130	38	30	. 333	7 740	892	311.6	373 4
351	951	1 58	147 2	803	781	426	300	261	145	128	40	31	325	8 280	955	307.2	377 6
352	.953	1.72	147.5	872	849	449	308	267	132	123	43	31	. 306	8 860	1.02	302.7	381 1
353	954	1.86	147 7	946	919	474	312	269	116	116	45	32	284	9 420	1 09	298.4	385.0
354	956	1 93	147.9	982	955	486	314	270	115	115	46	32	. 275	9 670	1 11	297.6	388 6
355	954	1 78	147 7	907	882	460	311	270	131	123	44	31	298	9 080	1 05	302.5	385 4
356	053	1 66	147 5	841	810	438	307	267	143	128	41	31	317	8 580	989	306.7	382 3
357	955	1.50	147.8	772	752	423	200	257	166	133	39	28	333	8 000	922	318 0	387.0
359	954	1 38	147 6	701	682	396	275	235	178	130	36	28	335	7 440	858	324 0	383.8
350	055	1.30	147.9	631	615	360	256	200	202	126	34	26	353	6 860	790	336.2	387 0
360	953	1 11	147 5	563	548	342	240	225	214	120	91	25	400	6 270	722	342 6	382 3
361	055	1.11	147.8	528	516	330	261	242	222	112	28	24	457	5 780	666	352.0	396.2
262	052	071	147.5	102	102	220	265	242	224	105	20	22	509	5 380	620	354 0	392.2
362	054	004	147 7	450	450	327	278	266	241	02	22	21	579	4 800	553	364.2	394 2
264	052	. 50-1	147 6	400	415	991	200	200	231	79	10	10	659	4 174	491	360.6	201.1
304	. 505	.030	147.4	444	410	220	200	210	221	75	10	10	.000	4 020	. 101	303.0	200.7
366	954	803	147 7	408	401	326	301	202	108	66	17	18	718	3 730	429	377 1	394.2
267	. 554	.002	141.1	400	207	227	201	200	197	62	16	17	794	2 610	. 123	270.0	204.2
260		796	147.6	300	304	397	305	207	181	62	16	17	745	3 520	406	370 1	393 0
260		. 100	147.0	204	294	221	200	291	179	50	16	177	760	2 420	204	319.1	202.0
309	052	762	147.5	387	202	325	300	200	162	55	14	16	774	3 200	380	380.3	303.0
971	052	759	141.0	389	303	320	301	300	155	59	12	16	707	3 190	367	300.3	301.9
979	052	747	147.0	380	375	325	307	2001	147	51	12	15	700	3 1 00	358	374 7	390.7
379	051	749	147 9	370	379	394	303	205	142	40	19	15	729	3 020	340	979 0	378 4
374	940	724	146 0	272	360	325	201	200	121	42	11	14	729	2 740	316	368 5	310.4
	. 343		140.0	· · · [	309 [		231	<u> </u>	***	"	<u> </u>	<u> </u>	. 132	2 130	. 510	500.5	010.7

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## (h) Reduced temperature, 1.031

	Reading	Reduced	Reduced	Stagnation			Pre	ssur	e at	static	on -			Ratio of throat	Maximum	Reduced	Saturation	pressure,
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		temper-	pres-	tempera-					5	_ _ ا	7	9	۵	pressure to	mass flow	mass	P <sub>sat</sub> ,	at -
Tr         Br         To         To<		ature,	sure,	ture,	1	4	°,	1	1	ľ	l '	0	Ĩ	stagnation	rate,	flow	Stagnation	Stagnation
$ \begin{array}{ c c c c c c c c c c c c c c c c c c c$		Tr	P <sub>r</sub>	T <sub>0</sub>		[			l					pressure,	G <sub>max</sub> ,	rate,	entropy.	tempera-
Image: 1.031         1.58         159.7         700         70           1106         1.031         1.48         150.7         700         673         4         610         0.531         497.1         (L)           1108         1.039         1.34         150.3         666         623         539         447         10         75         16         0.641         4020         .567         493.5         10         10         155.6         10         423         11         75         440         .677         493.5         11         10         .568         2260         .204												Í		<sup>P</sup> t <sup>/P</sup> 0	$g/(cm^2)(sec)$	<sup>G</sup> r	S.	ture.
1         1         1         1         1         1         0									ł			ł					-0	То
190         1.031         1.50, 7         100         95, 54, 48, 471         220         86         21         16         0.673         4610         0.531         467, 1         (m)           190         1.036         1.15         1.50, 3         666         622         539         63         477         101         715         4140         .478         493.3           100         1.035         1.15         1.55, 5         54         404         537         236         236         236         237         443         37         237         443.5         321         336         411         7         556         2360         .227         443.3         336         33         30         2         556         2360         221         437.3         461.0         361.0         362         233         330         30         2         556         2560         220         240.3         366.0         360.0         220.2         240.2         220.2         240.2         240.2         240.2         240.2         240.2         240.2         240.2         240.2         240.2         240.2         240.2         240.2         240.2         240.2         240.2         240.2																		-0
197       1.086       1.64       1.087       1.	196	1.031	1.38	159.7	700	693	544	488	471	223	85	21	16	0.673	4 610	0.531	487.1	(a)
198         1.029         1.105.3         165.3         668         662         593         632         647         715         4         1.0         .4768         493.3           200         1.028         1.11         159.1         658         559         64         31         11         7         .566         2.560         .224         .433.3           200         1.020         1.04         159.5         545         464         31         20         41         17         .566         2.560         2.22         433.3           200         1.001         .004         159.5         543         464         357         220         2.622         2.512         1.760         .220         332.7           201         1.032         .697         1.60.0         2.52         2.72         2.71         3         5.512         1.600         .162         1.32         2.32         1.12         3         6         5.512         1.600         .60         .60         .60         .60         .60         .60         .60         .60         .60         .60         .60         .60         .60         .60         .60         .60         .60         .60<	197	1.038	1.45	160.7	736	728	559	491	472	238	91	22	16	. 641	4 920	. 567	488.5	
199         1.026         1.18         156.9         569         504         503         352         151         54         131         1.585         3<120         .360            200         1.030         1.07         155.5         54         504         440         357         122         126         45         10         5         .5633         2200         .2201         41.21           200         1.030         .974         1.05.6         63         643         323         310         113         40         9         2         .5633         1.030         .222         312.7         70	198	1.029	1.31	159.3	668	662	539	493	477	201	75	18	15	. 715	4 140	. 478	493.3	
10.08       1.11       150.1       553       559       469       771       350       124       10       5       569       2360       .272       443.3         202       1.002       1.04       155.5       453       483       351       10       10       4       .586       2260       .511       112.4       19       2       .628       2060       .541       453.6       453.6       113       46       92       .6263       190.3       .522       2060       .561       173.6       175.6       453.4       113       16       92       .6283       2060       .222       312.7       .202       262.7       .203       16.03       .666       182       250.7       .222       10.33       .667       155.8       11       156       136       136       15       51       157.6	199	1.026	1.18	158.9	598	594	506	390	352	151	54	13	11	. 588	3 120	.360		
201       1.030       1.07       159.5       544       340       448       357       322       122       45       10       5       599       2 200       .240       364.5         203       1.030       .971       155.5       458       448       353       310       110       40       9       2       .6629       2 200       .240       364.5         204       1.030       .994       155.6       459       443       558       8       2       .512       1760       .222       312.7         206       1.033       .667       150.8       361       360       022       06       02       3       512       1760       .222       312.7         206       1.033       .667       150.8       154       124       107       94       112       13       36       50.2       73       .512       158.0       144       148       .513       1400       .182       182.0         210       1.03       .362       155.8       154       450       162       10       16       .699       4500       .416       485.2         212       1.040       1.58       1.051	200	1.028	1.11	159.1	563	559	469	371	336	134	47	11	7	. 596	2 550	. 294		
202       1.032       1.04       159.9       529       524       429       531.3       10       10       4       .566       2.200       .261       412.1         204       1.030       .094       155.6       433.48       392       33.50       113       40       92       .566       1.903       .222       312.7         206       1.033       .839       160.0       464       312       126       842       127       7       3       512       1.760       .202       262.7         206       1.033       .697       160.0       364       30.27       207       17.03       160.0       364       30.27       207       17.03       6       4.509       6       670       .677       50.2         221       1.041       1.18       157.0       601       595       505       402       364       214       16       6509       3610      016       486.2         322       1.041       1.18       156.7       347       447       418       120       .568       5700       .564       479.4       476       486.5       170       474.2       476       486.5       120       116 <td>201</td> <td>1.030</td> <td>1.07</td> <td>159.5</td> <td>544</td> <td>540</td> <td>448</td> <td>357</td> <td>323</td> <td>126</td> <td>45</td> <td>10</td> <td>5</td> <td>. 593</td> <td>2 360</td> <td>. 272</td> <td>443.3</td> <td></td>	201	1.030	1.07	159.5	544	540	448	357	323	126	45	10	5	. 593	2 360	. 272	443.3	
200       1.030       .971       159.5       493       484       392       333       310       113       40       9       2       .629       2.060       .220       326.7         206       1.033       .839       160.0       426       421       326       200       663       1303       .222       312.7         206       1.033       .697       160.0       354       350       202       207       27       3       512       1500       162       222.6       1         207       1.033       .697       160.0       354       350       272       207       182       76       27       3       512       1200       162       220.6       122       20.004       73.3         209       1.033       .382       159.8       184       182       164       210       80       16       509       6700       .077       50.2         212       1.041       1.18       157.00       651       247       480       242       10       16       609       4000       .466       417.7       74.7       74.7       74.7       74.7       74.7       74.7       74.7       74.7	202	1.032	1.04	159.9	529	524	429	351	310	120	43	10	4	.586	2 260	. 261	412.1	
204       1.030       .104       139.6       .222       312.7         206       1.032       .769       159.8       312       36       30       222       200       66       2       7       3       512       1760       .222       226.7         206       1.033       .667       160.0       354.67       201       122       128       16       4       513       1400       182.0         208       1.023       .687       159.2       212       128       170       129       113       34       16       3       6       .512       1600       .664       48.7         208       1.033       .362       159.6       144       129       140       11       14       .669       3610       .416       465.2         21       1.041       1.18       164.6       65       524       476       64       119       28       19       .568       5700       .657       476.7         225       1.040       1.58       161.1       719       481       460       226       120       .649       4650       .790       470.9         21       1.66       165.1	203	1.030	.971	159.5	493	488	392	333	310	113	40	9		. 629	2 080	. 240	364.5	
100       1.033       .839       100.0       220       242       240       210       36       6       569       4300       .496       481.7       7.5.2         220       1.031       1.56       150       640       240       240       247       240       16       240       16       .669       4300       .496       481.7         322       1.040       1.56       164       640       247       140       24       20       .668       5700       .684       479.4       20       .497       640       510       .777       77.5       73       512       160       .610       .776.7       707       73	204	1.030	.904	159.6	459	454	355	280	261	107	38	9	2	. 568	1 930	. 222	312.7	
1.052       1.059       1.054       1.059       1.052       1.050       1.052       2.08         207       1.053       1.660       354       356       272       207       1.053       1.060       152       221       218       107       129       13       38       16       3       6       .513       1400       .182       128.70       7       50.9       670       .077       50.2       282       1.014       1.18       157.0       601       595       565       402       366       173       64       17       14       -609       3 610       .416       488.7         322       1.014       1.18       157.0       601       576       462       210       60       201       16       .699       4 300       .446       488.7         324       1.032       1.43       165.0       674       476.7       474.5       474       524       221       10       10       .519       6310       .727       474.2       .476.6       6500       .660       464       228       20       .476       6500       .660       476.6       .513       11.00       .7170.9       325       383       464	205	1.033	.839	160.0	426	421	326	248	218	98	35	8		. 512	1 760	. 202	262.7	
a. 1. 0.53       1. 0.53       1. 0.50       1. 0.50       1. 0.50       1. 0.50       1. 0.50       1. 0.50       1. 0.50       1. 0.50       1. 0.50       1. 0.51       1. 0.50       1. 0.51       1. 0.50       1. 0.51       1. 0.50       1. 0.51       1. 0.55       0.55 <t< td=""><td>200</td><td>1.032</td><td>.769</td><td>159.8</td><td>391</td><td>386</td><td>300</td><td>228</td><td>200</td><td>86</td><td>32</td><td></td><td></td><td>. 512</td><td>1 580</td><td>. 182</td><td>220.8</td><td></td></t<>	200	1.032	.769	159.8	391	386	300	228	200	86	32			. 512	1 580	. 182	220.8	
1.003       1.003       1.003       1.003       1.003       1.004       1.10       1.00 <td>201</td> <td>1.033</td> <td>.091</td> <td>150.0</td> <td>304</td> <td>300</td> <td>272</td> <td>207</td> <td>182</td> <td>10</td> <td>27</td> <td>0</td> <td>4</td> <td>. 313</td> <td>1 400</td> <td>. 102</td> <td>182.0</td> <td></td>	201	1.033	.091	150.0	304	300	272	207	182	10	27	0	4	. 313	1 400	. 102	182.0	
1.003       1.004       1.014       1.014       1.014       1.014       1.014       1.014       30.2         222       1.014       1.18       157.0       60.1       155       50.4       102       16       .609       3.010       .101       480.2         232       1.023       1.31       158.4       646       655       528       478       462       24       18       .6026       5700       .564       479.4         325       1.040       1.58       151.0       803       700       571       481       452       282       120       31       20       .519       6310       .727       474.2         326       1.047       1.71       162.1       871       843       452       282       120       1.476       6 860       .790       470.9         328       1.051       1.07       700       785       622       444       462       251       12       .646       5590       .691       474.6       6       333       .303       1.33       159.5       701       691       541       483       466       228       18       1.665       4550       5360       4644.8       40.6	200	1.020	.430	159.2	194	102	142	107	04	21	10	2	6	500	670	.094	(3.3 50.9	
$ \begin{array}{cccccccccccccccccccccccccccccccccccc$	322	1 014	1 18	157.0	601	505	505	402	366	173	64	17	14	609	3 610	. 011	495 2	
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	323	1.014	1.10	158.4	664	655	528	478	464	210	80	20	16	699	4 300	. 410	405.2	
1.030       1.03	324	1.032	1 45	159.8	734	724	550	479	460	244	76	24	18	626	5 070	584	479 4	
326       1.047       1.75       1.65       1.67       1.65       6.30       7.727       474.2         327       1.053       1.86       165.1       94       88       452       22       120       31       20       .615       6310       .727       474.2         327       1.053       1.86       165.1       94       88       456       220       124       32       20       .497       6590       .601       470.9       33         328       1.051       1.65       161.7       839       825       583       484       456       275       114       29       19       .544       5990       .691       476.6         330       1.038       1.51       160.7       770       756       52       28       87       22       16       .665       4660       .664       484.4       44       333       1.030       1.31       159.5       668       660       540       494       478       200       75       19       15       .716       4060       .468       494.8       333       1.030       1.31       159.5       535       507       107       403       371       10	325	1.040	1.58	161.0	803	790	571	481	456	266	109	28	19	. 568	5 700	657	476 7	
227       1.053       1.86       163.1       94       926       6.7       45       44       297       129       42       22       .476       6       680       .790       470.9       470.6       6.850       .750       6.691       476.6       6.850       750.9       650.6       650       640       640       640.9       631.0       750.9       750.1       661.5       611.1       161.1       2.850       .280       2.468.2       480.9       480.9       480.9       480.9	326	1.047	1.71	162.1	871	857	594	483	452	282	120	31	20	. 519	6 310	727	474 2	
328       1.051       1.79       162.7       909       893       606       485       451       290       1.497       6 590       .700       473.5         329       1.045       1.65       161.7       839       825       583       444       456       275       114       20       19       544       5 990       .601       476.6       6         331       1.030       1.38       159.5       701       69       544       460       226       102       26       102       266       102       266       466.5       4650       .536       484.4         332       1.030       1.31       159.5       666       660       50       449       476       200       75       19       15       16       12       .6664       440.8       333       1.030       1.18       159.5       599       59       507       404       367       145       52       13       10       .612       2 960       .341         344       .433       .333       1.032       1.04       158.4       499       343       330       1515       41       10       3.521       2 960       .224	327	1.053	1.86	163.1	943	926	617	485	449	297	129	34	20	. 476	6 850	. 790	470.9	
329       1.045       1.65       161.7       839       825       583       484       456       275       114       29       19      544       5.900      691       476.6         330       1.038       1.51       160.7       770       755       562       484       460       226       18      599       5.360      691       440.6         331       1.030       1.38       159.5       666       6540       494       476       200       75       19       15      716       4.060      468       494.8         333       1.033       1.24       159.9       632       626       521       426       315       1.61       12      604       3.410      933       506.4         335       1.032       1.11       159.7       545       58       480       317       315       141       10       4      591      250      260      414      44      433      433       1.032       1.04       159.4       455       893       377       309       115       41       10       3      522       1.900      247       386.0	328	1.051	1.79	162.7	909	893	606	485	451	290	124	32	20	. 497	6 5 9 0	. 760	473.5	
330 $1.038$ $1.51$ $160.7$ $770$ $758$ $562$ $484$ $460$ $256$ $102$ $28$ $18$ $.599$ $5360$ $.618$ $480.6$ 331 $1.030$ $1.38$ $159.5$ $701$ $691$ $541$ $483$ $466$ $228$ $87$ $22$ $16$ $.6655$ $4650$ $.556$ $484.4$ $332$ $1.031$ $1.31$ $159.5$ $668$ $660$ $540$ $4478$ $200$ $75$ $19$ $15$ $.716$ $4060$ $.468$ $494.8$ $333$ $1.033$ $1.24$ $159.9$ $625$ $525$ $226$ $87$ $15$ $16$ $12$ $.664$ $341$ $556$ $334$ $1.030$ $1.18$ $159.5$ $599$ $507$ $507$ $547$ $527$ $323$ $115$ $551$ $2250$ $.290$ $.341$ $$ $335$ $1.032$ $1.11$ $159.7$ $561$ $529$ $523$ $117$ $41$ $10$ $4$ $.591$ $2140$ $.247$ $387.9$ $336$ $1.030$ $.977$ $159.3$ $507$ $501$ $477$ $14$ $10$ $3$ $.552$ $1960$ $.241$ $368.0$ $339$ $1.034$ $.903$ $160.0$ $459$ $411$ $327$ $249$ $188$ $35$ $93$ $.513$ $1830$ $.211$ $226.6$ $341$ $1.030$ $.770$ $159.5$ $392$ $355$ $216$ $18$ $16$ $5$ $5111$ $1280$	329	1.045	1.65	161.7	839	825	583	484	456	275	114	29	19	.544	5 990	. 691	476.6	
331 $1.030$ $1.38$ $159.5$ $701$ $691$ $541$ $483$ $466$ $228$ $87$ $22$ $16$ $665$ $4$ $4650$ $536$ $484.4$ 332 $1.030$ $1.11$ $159.5$ $668$ $605$ $540$ $494$ $476$ $200$ $75$ $19$ $15$ $716$ $4$ $4060$ $466$ $494.8$ 333 $1.030$ $1.18$ $159.5$ $652$ $526$ $632$ $426$ $322$ $167$ $61$ $16$ $12$ $.604$ $3410$ $393$ $506$ $334$ $1.032$ $1.11$ $159.7$ $564$ $558$ $668$ $372$ $355$ $18$ $12$ $7$ $.594$ $2530$ $.292$ $468.2$ $336$ $1.032$ $1.04$ $159.8$ $529$ $523$ $430$ $344$ $307$ $122$ $43$ $11$ $6$ $591$ $2140$ $.247$ $387.9$ $337$ $1.029$ $977$ $159.4$ $495$ $493$ $373$ $309$ $115$ $41$ $10$ $3$ $623$ $2090$ $.241$ $368.0$ $339$ $1.034$ $903$ $160.0$ $425$ $491$ $327$ $277$ $253$ $108$ $36$ $59$ $3$ $513$ $1830$ $.211$ $262.62$ $341$ $1.030$ $770$ $159.5$ $392$ $385$ $301$ $229$ $200$ $86$ $31$ $8$ $4$ $.511$ $1690$ $.125$ $344$ $1.031$ <	330	1.038	1.51	160.7	770	758	562	484	460	256	102	26	18	. 599	5 360	. 618	480.6	
332       1.030       1.31       159.5       668       660       540       494       478       200       75       19       15       .716       4060       .468       494.8         333       1.033       1.24       159.5       652       652       426       382       167       61       16       12       .604       3410       .333       506.4         334       1.030       1.18       159.5       599       533       507       404       367       145       52       13       10       .612       2960       .341          335       1.032       1.11       159.5       564       558       420       341       307       122       43       11       4       .591       2140       .247       387.9         336       1.034       .903       160.0       459       451       353       277       253       108       38       10       3       .552       1960       .226       306.2         340       1.033       .838       159.9       426       419       327       249       18       98       5       9       3       .513       1830       .211 <td>331</td> <td>1.030</td> <td>1.38</td> <td>159.5</td> <td>701</td> <td>691</td> <td>541</td> <td>483</td> <td>466</td> <td>228</td> <td>87</td> <td>22</td> <td>16</td> <td>. 665</td> <td>4 650</td> <td>. 536</td> <td>484.4</td> <td></td>	331	1.030	1.38	159.5	701	691	541	483	466	228	87	22	16	. 665	4 650	. 536	484.4	
333       1.033       1.24       159.9       632       626       532       426       382       167       61       16       12       .604       3410       .393       506.4         334       1.030       1.18       159.5       599       593       507       404       367       145       52       13       10       .612       2960       .341          335       1.032       1.04       159.8       529       523       403       371       307       12       5681       2550       .260       414.4         337       1.029       .977       159.3       507       501       407       324       11       5       581       2140       .247       387.9         338       1.030       .975       159.4       495       497       327       253       108       36       10       3       .5252       1960       .226       306.2         340       1.030       .903       160.0       459       371       327       25       108       85       5       9       5       513       1800       .211       26.6       306.2         341       1.030 <td< td=""><td>332</td><td>1.030</td><td>1.31</td><td>159.5</td><td>668</td><td>660</td><td>540</td><td>494</td><td>478</td><td>200</td><td>75</td><td>19</td><td>15</td><td>. 716</td><td>4 060</td><td>. 468</td><td>494.8</td><td></td></td<>	332	1.030	1.31	159.5	668	660	540	494	478	200	75	19	15	. 716	4 060	. 468	494.8	
334       1.030       1.18       159.5       599       593       507       404       367       145       52       13       10       .612       2 960       .341          335       1.032       1.11       159.7       564       586       488       377       351       135       48       12       7       .594       2 500       .292       466.2         336       1.032       1.04       159.3       507       501       407       345       299       117       41       10       4       .591       2140       .247       387.9         338       1.030       .975       159.4       495       489       342       18       8       10       3       .623       2090       .241       366.0         340       1.033       .838       159.4       327       285       81       8       4       .511       1690       .195       224.4         342       1.031       .703       159.6       357       352       275       209       183       76       27       7       4       .512       1550       .179       188.3         343       1.030       .51	333	1.033	1.24	159.9	632	626	532	426	382	167	61	16	12	. 604	3 410	. 393	506.4	
335       1.032       1.11       159.7       564       558       468       372       335       135       48       12       7       .594       2 530       .292       468.2         336       1.032       1.04       159.8       529       523       430       344       307       122       43       11       5       .561       2 250       .260       414.4         337       1.032       .977       159.3       507       501       407       345       299       117       41       10       3       .552       1960       .247       387.9         338       1.030       .975       159.4       495       49       341       309       15       41       10       3       .552       1960       .226       306.2         340       1.030       .638       159.9       426       419       327       29       200       86       31       8       4       511       1600       .226       306.2         341       1.030       .636       159.4       323       318       249       189       76       27       7       4       .512       1430       .165       154.3	334	1.030	1.18	159.5	599	593	507	404	367	145	52	13	10	. 612	2 960	. 341		
336       1.032       1.04       159.8       529       523       430       344       907       122       43       11       5       .581       2 250       .260       414.4         337       1.029       .977       159.3       507       501       407       345       299       117       41       10       4       .591       2 140       .247       387.9         338       1.030       .975       159.4       495       489       394       337       309       115       41       10       3       .623       2 090       .241       366.0         339       1.034       .903       160.0       459       35       277       253       10       3       .552       1960       .226       306.2         340       1.030       .770       159.5       392       385       301       229       200       86       31       8       4       .511       1690       .195       224.4         343       1.030       .636       159.4       323       189       166       68       24       6       5       .511       1430       .165       154.3       3         344 <td>335</td> <td>1.032</td> <td>1.11</td> <td>159.7</td> <td>564</td> <td>558</td> <td>468</td> <td>372</td> <td>335</td> <td>135</td> <td>48</td> <td>12</td> <td>7</td> <td>. 594</td> <td>2 530</td> <td>. 292</td> <td>468.2</td> <td></td>	335	1.032	1.11	159.7	564	558	468	372	335	135	48	12	7	. 594	2 530	. 292	468.2	
3371.029.977159.350750140734529911741104.5912 140.247387.93381.030.975159.449548939433730911541103.6232 090.241366.03391.034.903160.045945135327725310838103.5521 960.226306.23401.033.838159.9426419327249218885593.5131830.211262.63411.030.770159.5392385301229200863184.5111 690.195224.43421.031.703159.6357352275209183762774.5121 550.179188.33431.031.666159.4323318249189166662465.5111 280.148120.53441.031.566159.61521481168877251039.505770.08935.23471.032.164159.7838165494115569.497610.07012.83821.0311.94159.687465	336	1.032	1.04	159.8	529	523	430	344	307	122	43	11	5	. 581	2 250	. 260	414.4	
338       1.030       .975       159.4       495       495       495       337       309       115       41       10       3       .623       2 090       .241       368.0         339       1.034       .903       160.0       459       451       353       277       253       108       35       9       3       .552       1960       .226       306.2         340       1.030       .770       159.5       392       385       301       229       200       86       31       8       4       .511       1690       .226       306.2         341       1.030       .770       159.6       357       322       275       209       86       31       8       4       .511       1690       .195       224.4         342       1.031       .703       159.6       357       322       275       209       183       76       27       7       4       .512       1430       .165       154.3         343       1.031       .566       159.4       323       318       249       129       123       71       60       21       6       5       .511       1280	337	1.029	. 977	159.3	507	501	407	345	299	117	41	10	4	. 591	2 140	. 247	387.9	
339       1.034       .903       160.0       459       451       353       277       253       108       38       10       3       .552       1960       .226       306.2         340       1.033       .838       159.9       426       419       327       249       218       98       35       9       3       .513       1830       .211       262.6       341         341       1.030       .770       159.5       392       385       301       229       200       86       31       8       4       .511       1690       .195       224.4         342       1.031       .763       159.6       327       229       108       86       24       6       5       .512       1430       .165       154.3         343       1.030       .666       159.6       288       282       222       169       147       60       21       6       5       .511       1280       .148       120.5       345         345       1.031       .298       159.6       152       148       116       8       77       25       10       3       9       .505       770       .	338	1.030	. 975	159.4	495	489	394	337	309	115	41	10	3	. 623	2 090	. 241	368.0	
340       1.033       .838       159.9       426       419       327       249       218       98       35       9       3       .513       1       1830       .211       262.6         341       1.030       .770       159.5       392       385       301       229       200       86       31       8       4       .511       1       690       .195       224.4         342       1.031       .703       159.6       357       352       275       209       183       76       27       7       4       .512       1       500       .195       224.4         343       1.031       .566       159.4       323       318       249       189       166       68       24       6       5       .511       1       130       .165       154.3         344       1.031       .666       159.6       122       169       147       60       21       6       5       .511       1280       .148       120.5       .511       1280       .148       120.5       .511       130       .161       159.7       83       81       65       49       11       15       56	339	1.034	.903	160.0	459	451	353	277	253	108	38	10	3	. 552	1 960	. 226	306.2	
341       1.030       .770       159.5       392       365       301       229       200       86       31       8       4       .511       1690       .195       224.4         342       1.031       .703       159.6       357       352       275       209       183       76       27       7       4       .512       1500       .179       188.3         343       1.031       .666       159.4       323       318       249       189       166       68       24       6       5       .511       1430       .165       154.3         344       1.031       .566       159.6       282       222       169       147       60       21       6       5       .511       1280       .148       120.5         345       1.031       .298       159.6       152       148       116       88       77       25       10       3       9       .505       770       .089       35.2         347       1.032       .164       159.7       83       81       65       49       41       15       5       6       9       .497       610       .070       12.8	340	1.033	. 838	159.9	426	419	327	249	218	98	35	9	3	. 513	1 830	. 211	262.6	
342       1.031       .103       139.6       337       322       273       209       183       76       27       7       4       .512       1500       .179       188.3         343       1.030       .636       159.4       323       318       249       189       166       68       24       6       5       .512       1430       .165       154.3         344       1.031       .566       159.6       288       282       222       169       147       60       21       6       5       .511       1280       .148       120.5         345       1.031       .433       159.7       220       216       170       129       112       37       16       4       8       .508       1010       .117       70.9       9         346       1.031       .298       159.6       152       148       116       87       25       10       3       9       .505       770       .089       35.2         347       1.032       .164       159.7       83       81       65       49       41       15       5       6       9       .497       610       .070	341	1.030	.770	159.5	392	385	301	229	200	86	31	8	4	.511	1 690	. 195	224.4	
343       1.030       .636       159.4       323       318       249       169       160       68       24       6       5       .512       1430       .165       154.3         344       1.031       .566       159.6       288       282       222       169       147       60       21       6       5       .511       1280       .148       120.5         345       1.031       .433       159.7       220       216       170       129       112       37       16       4       8       .506       1010       .117       70.9         346       1.031       .298       159.6       124       416       87       725       10       3       9       .505       770       0.89       35.2         347       1.032       .164       159.7       83       81       65       49       41       15       5       6       9       .497       610       .070       12.8         382       1.031       1.85       159.5       941       922       576       439       397       33       135       37       23       .421       7530       .869       435.5	342	1.031	. 703	159.6	357	352	275	209	183	76	27	7	4	. 512	1 550	. 179	188.3	
344       1.031       .366       135.6       262       222       169       147       60       21       65       5       .511       1260       .146       120.5         345       1.031       .433       159.7       220       216       170       129       112       37       16       4       8       .508       1010       .117       70.9         346       1.031       .298       159.6       152       148       116       88       7       25       10       3       9       .505       770       .089       35.2         347       1.032       .164       159.7       88       165       49       41       15       5       6       9       .497       610       .070       12.8         382       1.031       1.94       159.6       984       963       565       436       390       307       139       39       24       .397       7950       .916       429.9         383       1.031       1.72       159.6       874       857       563       447       413       291       127       34       22       .473       6.880       .794       447.5 <td>343</td> <td>1.030</td> <td>.030</td> <td>159.4</td> <td>323</td> <td>318</td> <td>249</td> <td>189</td> <td>100</td> <td>68</td> <td>24</td> <td>0</td> <td>5</td> <td>. 512</td> <td>1 430</td> <td>. 165</td> <td>154.3</td> <td></td>	343	1.030	.030	159.4	323	318	249	189	100	68	24	0	5	. 512	1 430	. 165	154.3	
346       1.031       .233       135.7       220       210       112       312       31       16       4       6       1.036       1010       1.11       10.9         346       1.031       .298       159.6       152       148       116       88       77       25       10       3       9       .505       770       .089       35.2         347       1.032       .164       159.7       83       81       65       49       41       15       5       6       9       .497       610       .070       12.8         382       1.031       1.94       159.6       944       92       576       39       397       303       135       37       23       .421       7       530       .869       435.5         384       1.031       1.72       159.6       874       857       563       447       413       291       127       34       22       .473       6       860       .794       447.5         385       1.032       1.65       159.7       839       823       559       454       425       283       121       32       21       .506       6470 <td>344</td> <td>1.031</td> <td>. 300</td> <td>159.0</td> <td>200</td> <td>202</td> <td>170</td> <td>109</td> <td>147</td> <td>27</td> <td>16</td> <td>4</td> <td>0</td> <td>509</td> <td>1 200</td> <td>. 148</td> <td>120.5</td> <td></td>	344	1.031	. 300	159.0	200	202	170	109	147	27	16	4	0	509	1 200	. 148	120.5	
347       1.032       .164       159.7       83       81       65       49       41       15       5       6       9       .497       610       .070       12.8         382       1.031       1.94       159.7       83       81       65       49       41       15       5       6       9       .497       610       .070       12.8         382       1.031       1.94       159.5       941       922       576       439       397       303       135       37       23       .421       7530       .869       435.5         384       1.031       1.72       159.6       874       857       563       447       413       291       127       34       22       .473       6       860       .794       447.5         385       1.032       1.65       159.7       839       823       559       454       425       283       121       32       21       .506       6470       .746       454.9         386       1.032       1.58       159.7       803       788       554       466       428       82       10       .580       5640       .667       4	346	1 031	208	150.6	152	149	116	223	112	25	10	- - -	9	505	770	. 111	25.0	
382       1.031       1.94       159.6       984       965       436       390       307       139       39       24       .397       7 950       .916       429.9         383       1.031       1.85       159.5       941       922       576       439       397       303       135       37       23       .421       7 530       .869       435.5         384       1.031       1.72       159.6       874       857       563       447       413       291       127       34       22       .473       6 880       .794       447.5         385       1.032       1.65       159.7       839       823       559       454       426       283       121       32       21       .506       6 470       .746       454.9         386       1.032       1.58       159.7       803       788       554       462       436       273       114       30       20       .543       6 040       .697       462.5       383         387       1.030       1.51       159.7       736       725       546       466       248       98       25       18       .619       5 210	347	1 032	164	159.0	83	81	65	40	41	15	5	6	9	497	610	. 009	12 8	
383       1.031       1.85       159.5       941       922       576       439       397       303       135       37       23       .421       7       530       .869       435.5         384       1.031       1.72       159.6       874       857       563       447       412       283       127       34       22       .473       6       680       .794       447.5       385       1.032       1.65       159.7       839       823       559       454       412       283       121       32       21       .506       6       470       .746       454.9       385       1.032       1.58       159.7       803       788       554       462       436       273       114       30       20       .543       6       040       .697       462.5       387       1.031       1.55.7       765       752       546       466       444       261       107       27       19       .580       5       640       .697       462.5       388       1.031       1.45       159.7       736       725       545       475       456       248       98       25       18       .619       5210	382	1.031	1 94	159.6	984	963	585	436	390	307	130	39	24	397	7 950	916	429 9	.
384       1.031       1.72       159.6       874       857       563       447       413       291       127       34       22       .473       6       680       .794       447.5         385       1.032       1.65       159.7       839       823       559       454       425       283       121       32       21       .506       6       6470       .746       454.9       385       1.032       1.58       159.7       803       788       554       462       273       114       30       20       .543       6       040       .697       462.5       387       1.031       1.51       159.7       765       752       546       466       444       261       107       27       19       .580       5       640       .697       462.5         387       1.031       1.45       159.7       736       725       545       475       456       248       98       25       18       .619       5<10	383	1.031	1 85	159.5	941	922	576	439	397	3.03	135	37	23	421	7 530	869	435 5	
385       1.032       1.65       159.7       839       823       559       454       425       283       121       32       21       .506       6470       .746       454.9         386       1.032       1.58       159.7       803       788       554       462       426       273       114       30       20       .543       6040       .697       462.5         387       1.030       1.51       159.5       765       752       546       466       444       261       107       27       19       .580       5640       .650       468.1         388       1.031       1.45       159.7       736       725       545       475       456       248       98       25       18       .619       5210       .601       477.1         389       1.38       159.6       703       693       542       468       229       87       22       17       .666       4 680       .539       485.7         390       1.31       159.6       667       659       540       495       479       199       74       19       15       .719       4 060       .469       496.2	384	1.031	1.72	159.6	874	857	563	447	413	291	127	34	22	. 473	6 880	. 794	447.5	
386       1.032       1.58       159.7       803       788       554       462       436       273       114       30       20       .543       6040       .697       462.5         387       1.030       1.51       159.5       765       752       546       466       444       261       107       27       19       .580       5640       .650       468.1         388       1.031       1.45       159.7       736       725       545       475       456       248       98       25       18       .619       5210       .601       477.1         389       1.38       159.6       703       693       542       485       468       229       87       22       17       .666       4 680       .539       485.7         390       1.31       159.6       667       659       540       495       479       199       74       19       15       .719       4 060       .469       496.2         391       1.24       159.5       631       624       529       428       384       171       62       16       13       .608       3 470       .400       506.3 <td>385</td> <td>1.032</td> <td>1.65</td> <td>159.7</td> <td>839</td> <td>823</td> <td>559</td> <td>454</td> <td>425</td> <td>283</td> <td>121</td> <td>32</td> <td>21</td> <td>. 506</td> <td>6 470</td> <td>.746</td> <td>454.9</td> <td></td>	385	1.032	1.65	159.7	839	823	559	454	425	283	121	32	21	. 506	6 470	.746	454.9	
387       1.030       1.51       159.5       765       752       546       466       444       261       107       27       19       .580       5 640       .650       468.1         388       1.031       1.45       159.7       736       725       545       475       456       248       98       25       18       .619       5 210       .601       477.1         389       1.38       159.6       703       693       542       485       468       229       87       22       17       .666       4 680       .539       485.7         390       1.31       159.6       667       659       540       495       479       199       74       19       15       .719       4 060       .469       496.2         391       1.24       159.5       631       624       529       428       384       171       62       16       13       .608       3 470       .400       506.3	386	1.032	1.58	159.7	803	788	554	462	436	273	114	30	20	. 543	6 040	. 697	462.5	
388       1.031       1.45       159.7       736       725       545       475       456       248       98       25       18       .619       5 210       .601       477.1         389       1.38       159.6       703       693       542       468       229       87       22       17       .666       4 680       .539       485.7         390       1.31       159.6       667       659       540       495       479       199       74       19       15       .719       4 060       .469       496.2         391       1.24       159.5       631       624       529       428       384       171       62       16       13       .608       3 470       .400       506.3       \$	387	1.030	1.51	159.5	765	752	546	466	444	261	107	27	19	. 580	5 640	. 650	468.1	
389       1.38       159.6       703       693       542       485       468       229       87       22       17       .666       4 680       .539       485.7         390       1.31       159.6       667       659       540       495       479       199       74       19       15       .719       4 060       .469       496.2         391       1.24       159.5       631       624       529       428       384       171       62       16       13       .608       3 470       .400       506.3       \$	388	1.031	1.45	159.7	736	725	545	475	456	248	98	25	18	. 619	5 210	. 601	477.1	
390         1.31         159.6         667         659         540         495         479         199         74         19         15         .719         4 060         .469         496.2           391         1.24         159.5         631         624         529         428         384         171         62         16         13         .608         3 470         .400         506.3         V	389		1.38	159.6	703	693	542	485	468	229	87	22	17	. 666	4 680	. 539	485.7	
391   🕴   1.24   159.5   631   624   529   428   384   171   62   16   13   .608   3 470   .400   506.3   🌹	390		1.31	159.6	667	659	540	495	479	199	74	19	15	. 719	4 060	. 469	496.2	
	391	¥	1.24	159.5	631	624	529	428	384	171	62	16	13	. 608	3 470	. 400	506.3	Y

<sup>a</sup>Not applicable.

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#### TABLE VI. - Concluded.

## (i) Reduced temperature, 1.51

| Reading    | Reduced                  | Reduced     | Stagnation |     |            | Pr  | essui | e at  | statio | on - |        | L,   | Ratio of throat | Maximum<br>mass flow                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | Reduced            | Saturation                    | pressure,      |
|------------|--------------------------|-------------|------------|-----|------------|-----|-------|-------|--------|------|--------|------|-----------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-------------------------------|----------------|
|            | ature,<br>T <sub>r</sub> | Press<br>Pr | ture,      | 1   | 2          | 3   | 4     | 5     | 6      | 7    | 8      | 9    | $P_{t}/P_{0}$   | $G_{max}$ , | flow<br>rate,<br>G | sat<br>Stagnation<br>entropy, | Stagnation     |
|            |                          |             |            |     |            |     |       |       |        |      |        |      |                 | g/(cm )(sec)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | r r                | s <sub>o</sub>                | ture,          |
|            |                          |             | ļ          |     |            |     | ļ     | ļ     | ļ      |      |        |      | _               | 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                    |                               | T <sub>0</sub> |
| 36         | 1.57                     | 0. 429      | 242.7      | 218 | 215        | 168 | 125   | 109   | 35     | 12   | 14     | 22   | 0.499           | 560                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 0.065              | 10.1                          | (a)            |
| 37         | 1.55                     | . 425       | 239.6      | 216 | 214        | 166 | 124   | 108   | 35     | 11   | 3      | 8    | . 500           | 580                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | . 067              | 10.1                          | 1              |
| 38         | 1.50                     | . 562       | 233.0      | 286 | 282        | 221 | 164   | 145   | 46     | 15   | 18     | 29   | . 507           | 760                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | . 087              | 11.4                          |                |
| 39         | 1.50                     | . 562       | 232.2      | 286 | 281        | 221 | 163   | 145   | 45     | 15   | 4      | 8    | . 507           | 770                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | . 089              | 11.7                          |                |
| 40         | 1.49                     | . 425       | 230.3      | 216 | 213        | 168 | 124   | 110   | 34     | 11   | 3      | 8    | . 507           | 570                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | . 065              | 10.1                          |                |
| 41         | 1.48                     | . 429       | 229.3      | 218 | 215        | 170 | 125   | 111   | 34     | 11   | 12     | 20   | . 508           | 580                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | . 067              | 10.1                          |                |
| 42         | 1.50                     | . 699       | 232.0      | 355 | 351        | 275 | 203   | 182   | 55     | 19   | 9      | 19   | . 511           | 940                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | . 108              | 17.2                          |                |
| 43         | 1.50                     | . 698       | 232.3      | 355 | 351        | 274 | 202   | 182   | 55     | 19   | 5      | 7    | . 512           | 940                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | . 108              | 17.1                          |                |
| 44         | 1.51                     | . 835       | 234.3      | 424 | 419        | 327 | 242   | 217   | 66     | 22   | 6      | 8    | . 512           | 1 120                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | . 129              | 22.0                          |                |
| 45         | 1.53                     | .969        | 236.6      | 492 | 487        | 378 | 280   | 252   | 76     | 25   | 6      | 8    | . 512           | 1 290                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | . 149              | 27.1                          |                |
| 46         | 1.54                     | 1.11        | 239.1      | 562 | 555        | 426 | 320   | 287   | 85     | 29   | 7      | 8    | . 511           | 1 460                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | . 168              | 32.2                          |                |
| 47         | 1.56                     | 1.24        | 241.6      | 630 | 624        | 469 | 357   | 320   | 95     | 31   | 8      | 9    | . 508           | 1 600                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | . 185              | 37.6                          |                |
| 48         | 1.58                     | 1.38        | 244.2      | 700 | 694        | 562 | 392   | 351   | 102    | 33   | 9      | 9    | . 502           | 1 730                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | .199               | 43.0                          |                |
| 49         | 1.58                     | 1.38        | 244.9      | 700 | 694        | 543 | 389   | 351   | 99     | 32   | 12     | 32   | . 501           | 1 640                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | . 189              | 42.2                          | ¥              |
|            |                          |             |            |     |            |     | (j    | ) Red | luced  | temp | Derat  | ure, | 1.67            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                    | •                             |                |
| <b>F</b> , | 1 70                     | 0 100       |            | 017 |            | 100 | 100   | 107   | 0.5    |      |        |      | 0.400           | 500                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 0.001              | 10.1                          |                |
| 50         | 1.72                     | 0.428       | 266.9      | 217 | 213        | 107 | 123   | 107   | 30     | 11   | 17     | 1    | 0.493           | 530                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 0.001              | 10.1                          | (a)            |
| 52         | 1.00                     | -430        | 200.8      | 210 | 214        | 210 | 123   | 100   | 30     | 11   | 11     | 20   | . 493           | 720                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | . 003              |                               |                |
| 53         | 1.00                     | . 303       | 257.5      | 201 | 202        | 072 | 202   | 143   | 57     | 10   | ა<br>ი |      | . 491           | 130                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | 104                |                               |                |
| 55         | 1.00                     | .099        | 250.5      | 425 | 331<br>410 | 210 | 202   | 212   | 68     | 19   | 5      | , '  | . 499           | 1 090                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 126                | 12 0                          |                |
| 56         | 1.00                     | 071         | 257.1      | 403 | 497        | 378 | 280   | 212   | 80     | 20   | 6      | 8    | . 450           | 1 270                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 146                | 16.3                          |                |
| 57         | 1.68                     | 1 04        | 250.0      | 561 | 555        | 431 | 310   | 280   | 91     | 20   | 7      | 8    | 499             | 1 450                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 167                | 10.0                          | 1              |
| 58         | 1 69                     | 1 94        | 261 9      | 631 | 624        | 484 | 358   | 315   | 101    | 34   | 8      | a    | 498             | 1 630                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 188                | 22 9                          |                |
| 59         | 1 71                     | 1 38        | 264 0      | 699 | 693        | 536 | 398   | 349   | 112    | 38   | 9      | 10   | 499             | 1 810                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 208                | 26.2                          |                |
| 60         | 1.67                     | 969         | 258 9      | 492 | 486        | 378 | 280   | 246   | 79     | 26   | 6      | 8    | 499             | 1 270                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | 146                | 16.0                          |                |
| 61         | 1.65                     | 699         | 255.0      | 355 | 350        | 273 | 202   | 177   | 57     | 19   | 4      | 7    | 498             | 910                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | .105               | 10.1                          |                |
| 62         | 1.63                     | . 429       | 251.6      | 218 | 213        | 167 | 123   | 108   | 35     | 11   | 2      | 7    | . 494           | 550                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | . 064              | 10.1                          | ¥              |
|            |                          |             |            |     |            |     |       |       | l      |      | -      | '    |                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | [                  | ]                             |                |

<sup>a</sup>Not applicable.

#### TABLE VII. - ELLIPTICAL NOZZLE DATA FOR NITROGEN

#### (a) Reduced temperature, 0.645

| 1 | Reading | Reduced | Reduced        | Stagnation     |     |     | Pres | sure | at si | tation | -   |          |      | Ratio of throat                | Maximum            | Reduced        | Saturation       | pressure,                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---|---------|---------|----------------|----------------|-----|-----|------|------|-------|--------|-----|----------|------|--------------------------------|--------------------|----------------|------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|   |         | temper- | pres-          | tempera-       |     |     |      |      | 1     |        |     | 0        |      | pressure to                    | mass flow          | mass           | P <sub>sat</sub> | at -                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   |         | ature,  | sure,          | ture,          | 1   | z   | 3    | 4    | 5     | в      | l Y | 0        | 9    | stagnation                     | rate,              | flow           | C 4 +            | <b>Bk</b> - <b>B</b> |
|   |         | $T_r$   | P <sub>r</sub> | T <sub>0</sub> |     |     |      |      |       |        |     |          |      | pressure,                      | G <sub>max</sub> , | rate,          | ontrony          | tomner                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|   |         |         |                |                |     |     |      |      |       |        |     |          |      | P <sub>t</sub> /P <sub>0</sub> | $g/(cm^2)(sec)$    | G <sub>r</sub> | s entropy,       | tempera-                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|   |         |         |                |                |     |     |      |      |       | -      | Ì   |          |      |                                |                    |                | 50               | T T                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|   |         |         |                |                |     |     |      |      |       |        |     |          |      |                                |                    |                |                  | 10                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|   | 425     | 0.651   | 0.439          | 82.2           | 150 | 142 | . 50 | 21   | 14    | 12     | 9   | 8        | 9    | 0.097                          | 4 250              | 0.708          | 16.5             | 17.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 426     | . 648   | .640           | 81.8           | 219 | 208 | 68   | 24   | 1     | 12     | 9   | 6        | 7    | . 066                          | 5 230              | . 870          | 15.5             | 16.6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 1 | 427     | . 645   | . 832          | 81.5           | 284 | 271 | 86   | 27   | { }   | 12     | 9   |          | 5    | . 049                          | 6 02 0             | 1.00           | 14.8             | 16.1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 428     | . 643   | 1.04           | 81.2           | 355 | 338 | 107  | 31   |       | 11     | 8   |          | 4    | . 039                          | 6 760              | 1.12           | 14.0             | 15.5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 429     | . 641   | 1.25           | 80.9           | 426 | 405 | 127  | 34   | 1     |        |     |          |      | . 033                          | 7 430              | 1.24           | 13.3             | 15.1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 430     | . 638   | 1.44           | 80.6           | 492 | 470 | 145  | 37   | 13    |        |     | •        |      | . 027                          | 8 020              | 1.33           | 12.7             | 14.6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 431     | . 636   | 1.64           | 80.4           | 560 | 535 | 161  | 41   | 11    | ♥      |     | 5        |      | . 024                          | 8 5 9 0            | 1.43           | 12.1             | 14.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 432     | . 634   | 1.85           | 80.1           | 631 | 603 | 179  | 44   |       | 10     |     |          |      | . 021                          | 9 1 4 0            | 1.52           |                  | 13.8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 433     | . 632   | 2.06           | 79.8           | 704 | 672 | 199  | 49   |       |        | 7   |          |      | . 019                          | 9 680              | 1.61           |                  | 13.4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| ļ | 434     | . 633   | 1.94           | 80.0           | 664 | 634 | 188  | 47   |       |        | 7   | ¥        |      | . 020                          | 9 400              | 1.56           |                  | 13.6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 435     | . 636   | 1.75           | 80.3           | 599 | 571 | 171  | 43   | 🕴     | [♥     | 8   | 6        |      | . 022                          | 8 900              | 1.48           |                  | 14.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 436     | . 638   | 1.55           | 80.6           | 529 | 504 | 153  | 39   | 14    | 11     |     |          |      | . 026                          | 8 320              | 1.38           | 12.5             | 14.5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 437     | . 640   | 1.34           | 80.9           | 459 | 437 | 136  | 36   | 11    | 11     |     |          |      | . 030                          | 7 740              | 1.29           | 13.1             | 15.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 438     | . 643   | 1.15           | 81.2           | 392 | 373 | 117  | 33   |       | 12     |     |          |      | . 036                          | 7 120              | 1.18           | 13.8             | 15.5                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 439     | . 645   | .944           | 81.5           | 323 | 307 | 98   | 29   |       |        | }   |          | 1    | . 045                          | 6 420              | 1.07           | 14.5             | 16.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 440     | . 648   | . 746          | 81.8           | 255 | 243 | 78   | 26   | *     |        | 9   |          | 5    | . 055                          | 5 680              | .946           | 15.4             | 16.6                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 441     | . 649   | . 645          | 81.9           | 220 | 209 | 69   | 24   | 12    |        |     | <b>V</b> | 6    | . 066                          | 5 250              | . 873          | 15.8             | 16.8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 1 | 442     | . 651   | .546           | 82.2           | 187 | 177 | 59   | 23   | 14    | 1 🕴    |     | 7        | 8    | . 078                          | 4 800              | . 798          | 16.3             | 17.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 443     | . 654   | . 338          | 82.6           | 115 | 110 | 42   | 20   | 15    | 13     |     | 10       | 10   | . 130                          | 3 680              | . 612          | 17.4             | 18.0                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 444     | . 656   | . 285          | 82.8           | 97  | 92  | 37   | 19   | 15    | 13     |     |          |      | . 154                          | 3 320              | . 552          | 17.9             | 18.4                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 445     | .657    | . 233          | 83.0           | 80  | 76  | 33   |      | 16    | 13     |     |          |      | . 195                          | 2 940              | . 489          | 18.4             | 18.8                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 446     | .659    | . 185          | 83.2           | 64  | 60  | 28   |      | 16    | 12     |     |          |      | . 254                          | 2 500              | . 416          | 18.8             | 19.2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 447     | . 663   | . 133          | 83.7           | 46  | 43  | 24   | 🕴    | 16    | 11     | 10  |          |      | . 352                          | 1 960              | . 327          | 20.0             | 20.1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|   | 448     | . 667   | . 083          | 84.3           | 28  | 27  | 20   | 17   | 14    | 10     | 9   | 1        |      | . 509                          | 1 270              | . 211          | 21.2             | 21.3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| 1 | 1       |         |                |                | 1   |     | I .  | 1    | L .   | l      | ĮI  |          | I    |                                | l                  |                |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | -       |         |                |                |     |     |      | (Ł   | ) Re  | duced  | tem | perat    | ure, | 1.031                          |                    |                |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 453     | 1.030   | 2.13           | 130.1          | 728 | 709 | 408  | 289  | 254   | 206    | 97  | 28       | 18   | 349                            | 6.070              | 1 01           | 281 3            | (a)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|   | 454     | 1.030   | 2.05           | 130.1          | 700 | 682 | 401  | 290  | 257   | 206    | 95  | 28       | 18   | .367                           | 5 850              | .973           | 284.9            | (4)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|   | 455     | 1.032   | 1,95           | 130.3          | 666 | 650 | 396  | 294  | 264   | 207    | 94  | 26       | 17   | . 397                          | 5 510              | .917           |                  |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 456     | 1.032   | 1.84           | 130.3          | 630 | 615 | 388  | 297  | 270   | 203    | 90  | 25       | 17   | . 429                          | 5 150              | .857           | 296.9            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 457     | 1.032   | 1.75           | 130.3          | 598 | 584 | 382  | 300  | 277   | 198    | 86  | 23       | 16   | . 464                          | 4 840              | . 805          | 301.5            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 1 | 458     | 1.031   | 1.65           | 130.2          | 562 | 550 | 374  | 304  | 285   | 190    | 81  | 21       | 15   | .507                           | 4 470              | .743           | 307.4            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 459     |         | 1.55           |                | 528 | 518 | 370  | 311  | 296   | 180    | 74  | 19       | 14   | , 561                          | 4 030              | .670           | 314.5            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 460     |         | 1,45           |                | 495 | 486 | 366  | 319  | 307   | 167    | 66  | 17       | 13   | . 621                          | 3 560              | 593            | 321.4            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 461     | *       | 1.35           | ↓              | 462 | 455 | 364  | 329  | 320   | 146    | 54  | 14       | 12   | . 692                          | 3 030              | .504           | 329.5            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 462     | 1.030   | 1.24           | 130.1          | 425 | 419 | 355  | 289  | 262   | 115    | 42  | 11       | 11   | . 618                          | 2 3 9 0            | . 397          | 339.0            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 463     | 1.030   | 1.15           | 130.1          | 392 | 388 | 328  | 260  | 236   | 96     | 33  | 9        | 8    | . 602                          | 1 830              | . 305          | 335.9            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 464     | 1.031   | 1.05           | 130.3          | 358 | 354 | 292  | 232  | 209   | 83     | 29  | 9        | 6    | . 583                          | 1 540              | .256           | 288.7            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 465     | 1.033   | .950           | 130.4          | 325 | 320 | 254  | 211  | 198   | 77     | 27  | 8        | 4    | . 610                          | 1 370              | . 228          | 235.5            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 466     | 1.030   | . 846          | 130.1          | 289 | 284 | 222  | 169  | 150   | 68     | 24  | 7        | 5    | . 521                          | 1 190              | . 197          | 190.1            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| 1 | 467     |         | .745           |                | 254 | 250 | 195  | 147  | 129   | 55     | 20  | 6        | 6    | . 506                          | 990                | . 165          | 145.8            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 468     |         | . 642          |                | 219 | 215 | 168  | 127  | 111   | 45     | 17  | 5        | 6    | . 505                          | 810                | . 134          | 106.3            |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 469     |         | . 536          | ₩              | 183 | 179 | 140  | 106  | 92    | 35     | 13  | 4        | 7    | . 503                          | 620                | . 104          | 73.3             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 470     | 1.032   | . 437          | 130.3          | 149 | 147 | 115  | 86   | 74    | 25     | 10  | 4        | 8    | . 498                          | 490                | . 082          | 49.5             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 471     | 1.031   | . 336          | 130.2          | 115 | 112 | 88   | 66   | 57    | 19     | 8   | 6        | 8    | . 500                          | 370                | . 062          | 30.4             |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|   | 472     | 1.029   | . 233          | 130.0          | 80  | 70  | 61   | 46   | 40    | 13     | 5   | 7        | 10   | . 500                          | 200                | . 034          | 16.0             | •                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|   |         |         | . 1            |                | • 1 | ι.  |      | L.   |       |        | 1 1 | 1        |      |                                | ·                  |                |                  | · · · · · · · · · · · · · · · · · · ·                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

<sup>a</sup>Not applicable.

----

| Fluid              | Critical                              | Critical              | Critical                             | Compressibility | Mass                                                                               |
|--------------------|---------------------------------------|-----------------------|--------------------------------------|-----------------|------------------------------------------------------------------------------------|
|                    | P <sub>c</sub> ,<br>N/cm <sup>2</sup> | T <sub>c</sub> ,<br>K | $\rho_{\rm c},$<br>g/cm <sup>3</sup> | Z <sub>c</sub>  | rate<br>normalizing<br>parameter,<br>G <sup>*</sup> ,<br>g/(cm <sup>2</sup> )(sec) |
| Oxygen<br>Nitrogen | 508.3<br>341.7                        | 154.78<br>126.3       | 0.4325<br>.3105                      | 0.2922<br>.2937 | 8673.9<br>6010.4                                                                   |

| TABLE VIII CRITICAL | CONSTANTS | USED IN | REDUCING | PARAMETERS |
|---------------------|-----------|---------|----------|------------|
|---------------------|-----------|---------|----------|------------|

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Figure 1. Liquid oxygen choked flow test system.



Figure 2. - Cylindrical, perforated, baffle-type mixing chamber.



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Figure 4. - Elliptical-convergence test section.







Figure 5. - Data path for liquid-oxygen choked flow test runs.



Figure 6. - Choked flow rate and pressure ratio as function of reduced pressure and temperature - conical nozzle.



Figure 6. - Continued.

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Figure 6. - Continued.

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Figure 6. - Continued.

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Figure 6. - Continued.





Figure 6. - Continued.

I.





Figure 7. - Choked flow rate and pressure ratio as function of reduced pressure for oxygen in both conical and elliptical nozzles.



Figure 8. - Choked flow rate and pressure ratio as function of reduced pressure for nitrogen in two test facilities - conical nozzle.

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