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TABLES OF PRESSURE RATIOS P/P_c AND P/P_a FOR SUPERSONIC FLOW AROUND A 15° RIGHT CIRCULAR CONE AT ANGLES OF ATTACK

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LIST OF SYMBOLS

M_1	free-stream Mach number
P	local yawed pressure
P_a	ambient pressure
P_c	nonyawed conewall pressure
R	gas constant
S	entropy
c_p	specific heat at constant pressure
c_v	specific heat at constant volume
V	local velocity referred to limiting velocity
V_1	undisturbed velocity referred to limiting velocity
x	yaw contribution to the velocity component u
u, v, w or v_r, v_n, w	polar velocity components in the radial direction, normal to radial direction, and normal to meridian direction, respectively
α	angle of attack
δ	yaw of the axis of the conical shock with respect to the free-stream direction
γ	ratio of the specific heats
Θ	rotational angle denoting the position on the cross section of the solid cone.
ψ	position of the conical body in the $\Theta = \pi$ plane referred to the shock axis

Subscripts:

a	zero-order terms of Fourier series (part independent of angle of attack); except for P_a above

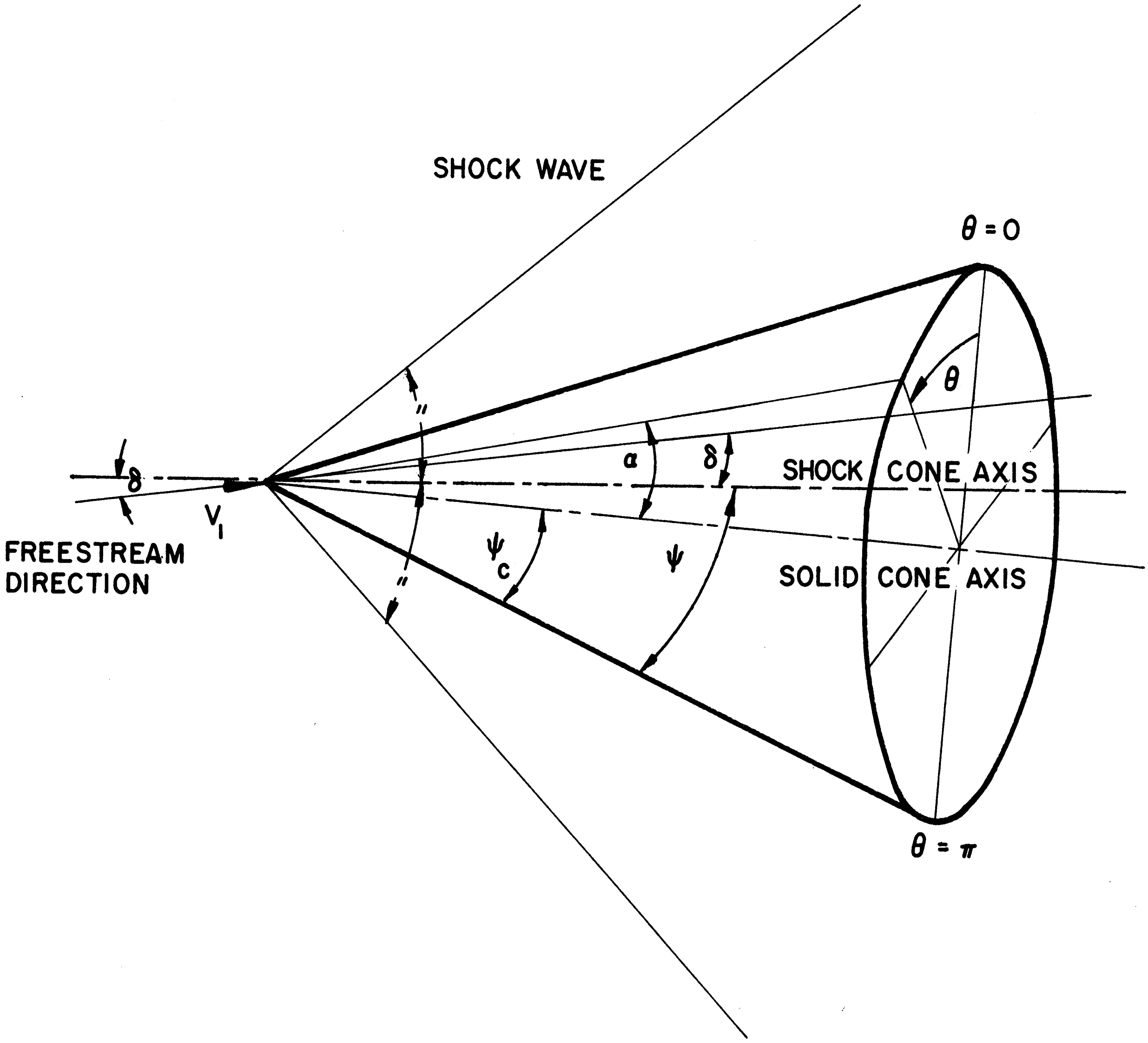
LIST OF SYMBOLS (Concluded)

b	first-order terms of Fourier series (part proportional to angle of attack)
c	cone surface values
e	quantities at external surface of vortical layer
n	referring to direction normal to the direction along a conical ray
r	referring to direction along a conical ray

ABSTRACT

For a right circular cone moving at supersonic velocities at zero angles of attack, measurement of the total head pressure and a conewall pressure enables determination of the ambient pressure and temperature.[1] The analysis is here extended to include corrections for small angles of attack with the use of Ferri's first-order theory.[2]

This report presents a tabulation of the ratio of the yawed conewall pressure to the ambient pressure, and the ratio of the yawed conewall to nonyawed conewall pressure at various rotational points on a 15° right circular cone for Mach numbers ranging from 2.0108 to 8.0589, and at angles of attack from 1 to 10°.



THE SOLID CONE AT SUPERSONIC FLOW
AT AN ANGLE OF ATTACK

INTRODUCTION

In axially symmetric supersonic flow around a right circular cone, where the direction of the stream is parallel to the axis of the cone, direct measurement of the total head pressure and the conewall pressure enables determination of the free-stream Mach number, the ambient pressure, and the ambient temperature. This technique was employed by this laboratory during the IGY with the use of Aerobee and Nike-Cajun rockets for the measurement of ambient pressure, temperature, and density in the 30- to 80-kilometer range over Fort Churchill, Canada.

Small angles of attack (of the order of 2° to 4°) were observed, and corrections to the nonyawed analysis can be made with the use of Ferri's theory.[2] From this theory, the ratio of the yawed conewall pressure to ambient pressure, and the yawed conewall to nonyawed conewall pressure are computed and tabulated for a 15° right circular cone.

DISCUSSION

The effect of finite angles of attack can be seen through the ratio of the yawed conewall pressure to the ideal, nonyawed, conewall pressure P/P_c. Calculation of P/P_c can be made through the following identity:

$$\frac{P}{P_c} = \frac{P}{P_a} \times \frac{P_a}{P_c}$$

where P/P_a is the ratio of the yawed to the ambient pressure, and P_a/P_c is the ratio of the ambient to the ideal nonyawed conewall pressure.

For the specific case of a 15° right circular cone, the ratio P_a/P_c has been calculated in Ref. 3. The expression for P/P_a is derived by Ferri, and is the basis for the computations in this report.

FERRI'S ANALYSIS

Ferri's determination for the supersonic flow around a cone at small angles of attack shows the existence of singular points at the surface of the cone in what he terms a "vortical layer." Across this layer the pressure distribution remains constant, but a discontinuity in entropy, density, and velocity occurs. In previous work, as in the Kopal Tables,[4,5] a computation from Stone's Theory, the flow properties were considered continuous. The analysis as developed by Ferri enables use of the Kopal values up to the point of the "vortical layer," after which the previously mentioned discontinuity in entropy is accounted for. The resulting pressure distribution, valid for small but finite angles of attack, is expressed as:

$$\frac{P}{P_a} = \left(\frac{1 - V^2}{1 - V_1^2}\right)^{\frac{\gamma}{\gamma-1}} \exp -\left(\frac{\Delta S}{R}\right) \tag{1}$$

COMPUTATION OF P/P_a

The expression given by P/P_a in Eq. (1) can be expanded, as suggested by Ferri, into a form where Kopal's tables may be used for the evaluation of the shock and conical flow properties, thus facilitating computation.

The steps leading up to the final expanded expression for P/P_a will be given.

(a) For a given Mach number M_1, V_1 is the undisturbed velocity referred to the limiting velocity, i.e., it is the ratio of the undisturbed velocity to the velocity that the air in front of the shock wave would have after an adiabatic expansion into a vacuum.

$$V_1^2 = \left(1 + \frac{2}{(\gamma - 1)M_1^2}\right)^{-1} \tag{2}$$

(b) $(\Delta S/R)$ is the increase in entropy per gas constant across the shock and is expressed in terms of S_a and S_b, the entropy change independent and dependent, respectively, of the angle of attack α.

$$\frac{\Delta S}{R} = \frac{S_a}{R} - \frac{\alpha S_b}{(\gamma - 1)c_v} \tag{3}$$

S_a is found in terms of the shock strength P_w/P_1 on page 555 of Kopal No. 1, and $S_b/c_v = d$ is tabulated on page 309 of Kopal No. 3.

(c) Corresponding to the yawed pressure P, V, the local velocity referred to the limiting velocity can be expressed in terms of its component polar velocities v_r, v_n, and w. Using the first-order Fourier series expansion as given by Ferri:

$$v_r = v_{r_a} + \alpha v_{r_b} \cos\theta$$

$$v_n = v_{n_a} + \alpha v_{n_b} \cos\theta \qquad (4)$$

$$w = \alpha w_b \sin\theta$$

where the subscript a refers to the part independent of the angle of attack, and b refers to the part dependent on the angle of attack. Denoting the subscript c as being on the surface of the cone where v_n is zero, V^2 becomes:

$$V^2 = (v_{r_{a_c}} + \alpha v_{r_{b_c}} \cos\theta)^2 + \alpha^2 w_{b_c}^2 \sin^2\theta \qquad (5)$$

In Ferri's analysis, the properties on the cone (with subscript c) are uniquely related to the quantities at the external surface of the previously mentioned "vortical layer" (denoted by the subscript e). The pressure distribution through the layer remains constant so that the pressure at the external surface of the "vortical layer" is equal to the cone surface pressure. A discontinuity in entropy, density, and velocity exists, but it is shown that the cone surface properties are only affected by the streamlines that cross the shock in the meridian plane $\theta = \pi$. In this $\theta = \pi$ plane, $S_e = S_c$, $v_{r_e} = v_{r_c}$ and $w_e = w_c = 0$. It is with these relationships that the terms in Eq. (5) above are established. This is done with the use of Eqs. (32), (34), (35), (37), and (55) of Ferri's report.

Since ultimate computation is with the use of the flow properties as calculated in Kopal's Tables, the terms in the equations referred to above are converted to the notation conforming to Kopal's. The polar velocity components v_r, v_n, and w used by Ferri correspond to u, v, and w used by Kopal. For example, $v_{r_{a_e}}$ in Ferri's report corresponds to u_ψ in Kopal's notation, and similarly $v_{n_{a_\psi}}$ corresponds to v_ψ where

$$\psi = \psi_c + \alpha - \delta \qquad (6)$$

ψ = position in the $\theta = \pi$ plane of the conical body referred to the shock axis

ψ_c = half angle of the solid cone

α = angle of attack

δ = inclination of the conical axis with respect to the free-stream direction.

Equations (32) and (55) from Ferri's report:

$$v_r' = (v_{r_a} - \alpha v_{r_b})_e = (v_{r_a} - \alpha v_{r_b})_c \qquad (7)$$

$$v_{r_{b_e}} = -\left(x_{\psi_c} + v_{n_{a_\psi}} \frac{\delta}{\alpha}\right) \qquad (8)$$

can be expressed in Kopal's notation as:

$$v_r' = u_\psi + \alpha x_{\psi_c} + \delta v_\psi \qquad (9)$$

$$v_{r_{b_e}} = -\left(x_{\psi_c} + v_\psi \frac{\delta}{\alpha}\right) \qquad (10)$$

Similarly Eqs. (34) and (37) from Ferri's report

$$v_{r_{b_c}} = \frac{a_e^2}{\gamma(\gamma - 1) v_r'} \frac{S_b}{c_v} + v_{r_{b_e}} \qquad (11)$$

$$a_e^2 = \frac{\gamma - 1}{2}(1 - v_r'^2) \qquad (12)$$

combine, and, in terms of Kopal's notation, with the use of Eqs. (9) and (10) above, $v_{r_{b_c}}$ becomes:

$$v_{r_{b_c}} = \frac{1 - (u_\psi + \alpha x_{\psi_c} + \delta v_\psi)^2}{2\gamma(u_\psi + \alpha x_{\psi_c} + \delta v_\psi)} \frac{S_b}{c_v} - \left(x_{\psi_c} + v_\psi \frac{\delta}{\alpha}\right) \qquad (13)$$

The term $v_{r_{a_c}}$ from Eq. (7), using (9), (10), and (13), becomes:

$$v_{r_{a_c}} = u_\psi + \alpha \left[\frac{1 - (u_\psi + \alpha x_{\psi_c} + \delta v_\psi)^2}{2\gamma(u_\psi + \alpha x_{\psi_c} + \delta v_\psi)} \frac{S_b}{c_v}\right] \qquad (14)$$

Finally, Eq. (35) from Ferri's report:

$$w_{b_c} = \frac{-v_{r_{b_c}}}{\sin \psi_c} \qquad (15)$$

and on substitution of Eq. (13):

$$w_{b_c} = \frac{-1}{\sin\psi_c}\;\frac{1-(u_\psi+\alpha x_{\psi_c}+\delta v_\psi)^2}{2\gamma(u_\psi+\alpha x_{\psi_c}+\delta v_\psi)}\,\frac{S_b}{c_v} - \left(x_{\psi_c}+v_\psi\frac{\delta}{\alpha}\right) \tag{16}$$

The above expressions for $v_{r_{a_c}}$, $v_{r_{b_c}}$, and w_{b_c} are substituted into Eq. (5) and give V^2 in terms of the quantities δ/α, u_ψ, v_ψ, x_{ψ_c}, and S_b/c_v which are tabulated in Kopal. This expanded expression for V^2 is:

$$V^2 = \left\{u_\psi + \alpha(1+\cos\theta)\,\frac{1-(u_\psi+\alpha x_{\psi_c}+\delta v_\psi)^2}{2\gamma(u_\psi+\alpha x_{\psi_c}+\delta v_\psi)}\,\frac{S_b}{c_v} - \alpha\cos\theta\left(x_{\psi_c}+v_\psi\frac{\delta}{\alpha}\right)\right\}^2$$
$$+\frac{\alpha^2\sin^2\theta}{\sin^2\psi_c}\left\{\frac{1-(u_\psi+\alpha x_{\psi_c}+\delta v_\psi)^2}{2\gamma(u_\psi+\alpha x_{\psi_c}+\delta v_\psi)}\,\frac{S_b}{c_v} - \left(x_{\psi_c}+v_\psi\frac{\delta}{\alpha}\right)\right\}^2 \tag{17}$$

When substituted into the Ferri expression for the yawed to the ambient pressure ratio P/P_a, Eq. (1) becomes:

$$\frac{P}{P_a} = \left\{\frac{1-\left\{u_\psi+\alpha(1+\cos\theta)\dfrac{1-(u_\psi+\alpha x_{\psi_c}+\delta v_\psi)^2}{2\gamma(u_\psi+\alpha x_{\psi_c}+\delta v_\psi)}\dfrac{S_b}{c_v} - \left(x_{\psi_c}+\dfrac{\delta}{\alpha}v_\psi\right)\alpha\cos\theta\right\}^2}{1-V_1^2}\right.$$
$$\left.-\frac{\dfrac{\alpha^2\sin^2\theta}{\sin^2\psi_c}\left\{\dfrac{1-(u_\psi+\alpha x_{\psi_c}+\delta v_\psi)^2}{2\gamma(u_\psi+\alpha x_{\psi_c}+\delta v_\psi)}\dfrac{S_b}{c_v} - \left(x_{\psi_c}+\dfrac{\delta}{\alpha}v_\psi\right)\right\}^2}{1-V_1^2}\right\}^{\frac{\gamma}{\gamma-1}} \exp -\left(\frac{\Delta S}{R}\right) \tag{18}$$

This is the final expression used for the computation for the values of P/P_a. For a given solid cone (e.g., $\psi_c = 7.5°$), at a given Mach number M_1, angle of attack α, and rotational angle θ, the quantities in Eq. (18) are determined as follows:

1. δ/α, S_b/c_v from Kopal No. 3, page 309.

2. ψ from Eq. (6) of this report.

3. u_ψ, v_ψ from Kopal No. 1, the values of u and v at the angle ψ.

4. x_{ψ_c} from Kopal No. 3, the value of x at the angle ψ_c.

5. V_1 for various Mach numbers M_1 from Eq. (2) of this report.

6. $\Delta S/R$ from Eq. (3) of this report.

These various quantities for the Mach number range 2.0108 to 8.0589 and angle of attack at 1° increments up to 10° were tabulated, and the computation for P/P_a from these quantities, through Eq. (18), was completed through the use of an IBM 704 computer.

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M = 2.0108

θ°	α = 1° P/P_a	α = 1° P/P_c	α = 2° P/P_a	α = 2° P/P_c	α = 3° P/P_a	α = 3° P/P_c	α = 4° P/P_a	α = 4° P/P_c	α = 5° P/P_a	α = 5° P/P_c
0.0	1.16275	0.98040	1.14220	0.96307	1.12384	0.94759	1.10757	0.93387	1.09320	0.92175
10.0	1.16303	0.98063	1.14259	0.96339	1.12415	0.94785	1.10762	0.93391	1.09280	0.92141
20.0	1.16388	0.98135	1.14377	0.96439	1.12515	0.94869	1.10789	0.93414	1.09181	0.92058
30.0	1.16529	0.98254	1.14580	0.96610	1.12700	0.95025	1.10874	0.93486	1.09083	0.91976
40.0	1.16725	0.98419	1.14876	0.96860	1.12997	0.95276	1.11072	0.93652	1.09079	0.91972
50.0	1.16976	0.98630	1.15274	0.97196	1.13437	0.95646	1.11445	0.93967	1.09276	0.92138
60.0	1.17277	0.98884	1.15781	0.97623	1.14048	0.96162	1.12057	0.94483	1.09785	0.92568
70.0	1.17625	0.99178	1.16399	0.98144	1.14853	0.96840	1.12963	0.95247	1.10703	0.93341
80.0	1.18012	0.99504	1.17124	0.98756	1.15862	0.97691	1.14196	0.96287	1.12099	0.94518
90.0	1.18430	0.99857	1.17946	0.99449	1.17069	0.98709	1.15766	0.97610	1.14001	0.96122
100.0	1.18867	1.00225	1.18844	1.00206	1.18449	0.99873	1.17644	0.99194	1.16390	0.98137
110.0	1.19308	1.00597	1.19788	1.01002	1.19956	1.01143	1.19771	1.00988	1.19191	1.00498
120.0	1.19738	1.00959	1.20740	1.01805	1.21524	1.02466	1.22051	1.02909	1.22273	1.03097
130.0	1.20140	1.01298	1.21657	1.02578	1.23074	1.03773	1.24355	1.04852	1.25455	1.05780
140.0	1.20497	1.01600	1.22493	1.03282	1.24516	1.04988	1.26538	1.06693	1.28520	1.08364
150.0	1.20794	1.01850	1.23201	1.03879	1.25757	1.06035	1.28444	1.08300	1.31232	1.10651
160.0	1.21018	1.02038	1.23740	1.04334	1.26714	1.06841	1.29929	1.09552	1.33365	1.12449
170.0	1.21156	1.02155	1.24078	1.04619	1.27318	1.07350	1.30873	1.10348	1.34729	1.13599
180.0	1.21203	1.02195	1.24193	1.04716	1.27524	1.07524	1.31197	1.10621	1.35198	1.13995

M = 2.0108

θ°	α = 6°		α = 7°		α = 8°		α = 9°		α = 10°	
	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c
0.0	1.08068	0.91120	1.06976	0.90199	1.06067	0.89433	1.05298	0.88784	1.04707	0.88286
10.0	1.07964	0.91032	1.06788	0.90041	1.05775	0.89186	1.04880	0.88432	1.04143	0.87810
20.0	1.07683	0.90795	1.06270	0.89604	1.04962	0.88501	1.03714	0.87449	1.02563	0.86478
30.0	1.07319	0.90489	1.05556	0.89001	1.03810	0.87530	1.02040	0.86037	1.00280	0.84553
40.0	1.07011	0.90229	1.04841	0.88399	1.02589	0.86500	1.00212	0.84496	0.97746	0.82417
50.0	1.06923	0.90155	1.04361	0.87994	1.01610	0.85675	0.98635	0.83166	0.95474	0.80501
60.0	1.07225	0.90409	1.04352	0.87987	1.01193	0.85323	0.97715	0.82391	0.93965	0.79228
70.0	1.08065	0.91118	1.05028	0.88557	1.01618	0.85681	0.97810	0.82471	0.93654	0.78967
80.0	1.09558	0.92376	1.06553	0.89842	1.03108	0.86938	0.99202	0.83644	0.94888	0.80007
90.0	1.11762	0.94234	1.09020	0.91923	1.05801	0.89208	1.02076	0.86068	0.97899	0.82545
100.0	1.14667	0.96684	1.12441	0.94807	1.09730	0.92521	1.06499	0.89797	1.02793	0.86672
110.0	1.18190	0.99654	1.16726	0.98420	1.14810	0.96804	1.12394	0.94768	1.09516	0.92341
120.0	1.22164	1.03005	1.21676	1.02594	1.20814	1.01867	1.19518	1.00774	1.17816	0.99339
130.0	1.26349	1.06534	1.26987	1.07071	1.27371	1.07395	1.27435	1.07449	1.27201	1.07253
140.0	1.30444	1.09986	1.32260	1.11517	1.33977	1.12965	1.35527	1.14272	1.36936	1.15460
150.0	1.34111	1.13078	1.37039	1.15548	1.40036	1.18074	1.43037	1.20604	1.46079	1.23169
160.0	1.37022	1.15533	1.40867	1.18775	1.44931	1.22202	1.49160	1.25767	1.53603	1.29514
170.0	1.38895	1.17112	1.43345	1.20864	1.48120	1.24890	1.53173	1.29151	1.58566	1.33698
180.0	1.39541	1.17657	1.44203	1.21588	1.49227	1.25824	1.54571	1.30330	1.60301	1.35161

M = 2.3105

θ°	$\alpha = 1^\circ$ P/P_a	P/P_c	$\alpha = 2^\circ$ P/P_a	P/P_c	$\alpha = 3^\circ$ P/P_a	P/P_c	$\alpha = 4^\circ$ P/P_a	P/P_c	$\alpha = 5^\circ$ P/P_a	P/P_c
0.0	1.19902	0.97561	1.17129	0.95304	1.14638	0.93277	1.12393	0.91450	1.10359	0.89796
10.0	1.19940	0.97591	1.17181	0.95347	1.14681	0.93313	1.12402	0.91458	1.10311	0.89757
20.0	1.20052	0.97683	1.17340	0.95476	1.14818	0.93424	1.12448	0.91495	1.10193	0.89661
30.0	1.20239	0.97835	1.17613	0.95698	1.15072	0.93631	1.12575	0.91599	1.10084	0.89572
40.0	1.20500	0.98047	1.18010	0.96021	1.15476	0.93960	1.12854	0.91825	1.10102	0.89587
50.0	1.20832	0.98317	1.18542	0.96454	1.16069	0.94442	1.13365	0.92242	1.10387	0.89818
60.0	1.21231	0.98642	1.19217	0.97003	1.16889	0.95109	1.14192	0.92914	1.11082	0.90384
70.0	1.21691	0.99016	1.20039	0.97672	1.17964	0.95984	1.15405	0.93901	1.12313	0.91386
80.0	1.22204	0.99433	1.21002	0.98456	1.19308	0.97077	1.17050	0.95240	1.14173	0.92899
90.0	1.22756	0.99883	1.22092	0.99343	1.20913	0.98383	1.19138	0.96939	1.16704	0.94958
100.0	1.23332	1.00352	1.23282	1.00311	1.22746	0.99875	1.21639	0.98974	1.19885	0.97546
110.0	1.23915	1.00826	1.24533	1.01329	1.24749	1.01505	1.24473	1.01280	1.23623	1.00588
120.0	1.24483	1.01288	1.25795	1.02355	1.26836	1.03203	1.27517	1.03757	1.27750	1.03947
130.0	1.25013	1.01720	1.27011	1.03345	1.28901	1.04883	1.30602	1.06267	1.32031	1.07429
140.0	1.25485	1.02104	1.28119	1.04246	1.30824	1.06448	1.33532	1.08651	1.36170	1.10797
150.0	1.25878	1.02423	1.29058	1.05011	1.32482	1.07797	1.36098	1.10738	1.39847	1.13790
160.0	1.26172	1.02662	1.29774	1.05593	1.33762	1.08838	1.38100	1.12368	1.42748	1.16150
170.0	1.26355	1.02811	1.30222	1.05958	1.34570	1.09496	1.39374	1.13405	1.44608	1.17663
180.0	1.26417	1.02861	1.30375	1.06082	1.34847	1.09721	1.39812	1.13761	1.45249	1.18185

M = 2.3105

θ°	α = 6°		α = 7°		α = 8°		α = 9°		α = 10°	
	P/P_a	P/P_c	P/P_g	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c
0.0	1.08553	0.88326	1.06951	0.87023	1.05527	0.85864	1.04263	0.84835	1.03212	0.83980
10.0	1.08421	0.88219	1.06708	0.86825	1.05147	0.85555	1.03717	0.84392	1.02471	0.83378
20.0	1.08066	0.87930	1.06042	0.86283	1.04092	0.84697	1.02196	0.83154	1.00403	0.81695
30.0	1.07609	0.87558	1.05125	0.85537	1.02602	0.83484	1.00020	0.81383	0.97427	0.79274
40.0	1.07231	0.87251	1.04215	0.84797	1.01028	0.82203	0.97654	0.79458	0.94144	0.76602
50.0	1.07144	0.87180	1.03615	0.84308	0.99777	0.81186	0.95626	0.77808	0.91219	0.74222
60.0	1.07568	0.87524	1.03631	0.84321	0.99257	0.80762	0.94452	0.76853	0.89287	0.72650
70.0	1.08697	0.88443	1.04540	0.85061	0.99832	0.81230	0.94589	0.76965	0.88895	0.72331
80.0	1.10683	0.90059	1.06559	0.86704	1.01793	0.82826	0.96404	0.78441	0.90481	0.73622
90.0	1.13608	0.92439	1.09823	0.89360	1.05334	0.85707	1.00153	0.81491	0.94367	0.76784
100.0	1.17473	0.95584	1.14363	0.93053	1.10526	0.89932	1.05961	0.86218	1.00742	0.81971
110.0	1.22177	0.99411	1.20082	0.97707	1.17293	0.95438	1.13785	0.92584	1.09616	0.89191
120.0	1.27513	1.03753	1.26739	1.03124	1.25370	1.02010	1.23359	1.00374	1.20746	0.98247
130.0	1.33166	1.08353	1.33940	1.08983	1.34287	1.09265	1.34146	1.09150	1.33546	1.08663
140.0	1.38730	1.12880	1.41149	1.14849	1.43366	1.16653	1.45319	1.18242	1.47044	1.19645
150.0	1.43741	1.16958	1.47732	1.20205	1.51774	1.23494	1.55815	1.26782	1.59910	1.30114
160.0	1.47736	1.20209	1.53036	1.24521	1.58621	1.29065	1.64456	1.33813	1.70626	1.38833
170.0	1.50316	1.22307	1.56485	1.27327	1.63105	1.32714	1.70159	1.38453	1.77753	1.44633
180.0	1.51208	1.23033	1.57682	1.28301	1.64667	1.33985	1.72153	1.40076	1.80256	1.46669

M = 2.6847

θ°	$\alpha=1^{\circ}$ P/P_a	$\alpha=1^{\circ}$ P/P_c	$\alpha=2^{\circ}$ P/P_a	$\alpha=2^{\circ}$ P/P_c	$\alpha=3^{\circ}$ P/P_a	$\alpha=3^{\circ}$ P/P_c	$\alpha=4^{\circ}$ P/P_a	$\alpha=4^{\circ}$ P/P_c	$\alpha=5^{\circ}$ P/P_a	$\alpha=5^{\circ}$ P/P_c
0.0	1.24819	0.96834	1.21009	0.93878	1.17506	0.91160	1.14256	0.88640	1.11271	0.86323
10.0	1.24870	0.96874	1.21081	0.93934	1.17567	0.91208	1.14274	0.88654	1.11211	0.86277
20.0	1.25023	0.96993	1.21300	0.94104	1.17762	0.91359	1.14350	0.88712	1.11070	0.86167
30.0	1.25278	0.97190	1.21676	0.94396	1.18119	0.91636	1.14542	0.88862	1.10950	0.86074
40.0	1.25632	0.97465	1.22221	0.94819	1.18683	0.92073	1.14944	0.89173	1.11006	0.86118
50.0	1.26083	0.97814	1.22950	0.95384	1.19503	0.92710	1.15662	0.89730	1.11423	0.86441
60.0	1.26624	0.98235	1.23873	0.96100	1.20631	0.93585	1.16806	0.90618	1.12392	0.87193
70.0	1.27249	0.98719	1.24994	0.96970	1.22103	0.94727	1.18471	0.91909	1.14081	0.88504
80.0	1.27943	0.99258	1.26307	0.97988	1.23939	0.96151	1.20719	0.93654	1.16620	0.90473
90.0	1.28691	0.99838	1.27790	0.99139	1.26130	0.97851	1.23572	0.95866	1.20071	0.93150
100.0	1.29472	1.00444	1.29409	1.00395	1.28634	0.99793	1.26991	0.98519	1.24419	0.96524
110.0	1.30260	1.01055	1.31110	1.01715	1.31371	1.01917	1.30876	1.01533	1.29552	1.00505
120.0	1.31028	1.01651	1.32828	1.03047	1.34227	1.04133	1.35061	1.04780	1.35251	1.04427
130.0	1.31746	1.02208	1.34484	1.04332	1.37060	1.06330	1.39321	1.08084	1.41197	1.09540
140.0	1.32385	1.02704	1.35994	1.05504	1.39703	1.08381	1.43381	1.11234	1.46983	1.14028
150.0	1.32916	1.03115	1.37276	1.06498	1.41986	1.10152	1.46950	1.14003	1.52151	1.18038
160.0	1.33314	1.03424	1.38252	1.07256	1.43752	1.11522	1.49743	1.16170	1.56247	1.21216
170.0	1.33561	1.03616	1.38865	1.07730	1.44868	1.12388	1.51525	1.17552	1.58881	1.23259
180.0	1.33645	1.03681	1.39073	1.07892	1.45250	1.12684	1.52137	1.18027	1.59791	1.23965

M = 2.6847

$\theta°$	α = 6° P/Pa	α = 6° P/Pc	α = 7° P/Pa	α = 7° P/Pc	α = 8° P/Pa	α = 8° P/Pc	α = 9° P/Pa	α = 9° P/Pc	α = 10° P/Pa	α = 10° P/Pc
0.0	1.08515	0.84186	1.05995	0.82230	1.03685	0.80439	1.01552	0.78784	0.99635	0.77296
10.0	1.08344	0.84053	1.05675	0.81982	1.03181	0.80047	1.00825	0.78219	0.98645	0.76528
20.0	1.07886	0.83698	1.04799	0.81302	1.01783	0.78963	0.98801	0.76649	0.95887	0.74389
30.0	1.07302	0.83244	1.03598	0.80371	0.99816	0.77437	0.95921	0.74415	0.91948	0.71333
40.0	1.06829	0.82877	1.02415	0.79453	0.97749	0.75834	0.92808	0.72000	0.87640	0.67991
50.0	1.06749	0.82815	1.01647	0.78857	0.96118	0.74568	0.90156	0.69943	0.83833	0.65038
60.0	1.07351	0.83282	1.01699	0.78897	0.95452	0.74051	0.88630	0.68758	0.81332	0.63097
70.0	1.08896	0.84481	1.02935	0.79857	0.96227	0.74653	0.88810	0.68899	0.80812	0.62694
80.0	1.11592	0.86573	1.05653	0.81965	0.98834	0.76675	0.91179	0.70736	0.82830	0.64259
90.0	1.15565	0.89655	1.10055	0.85380	1.03557	0.80339	0.96108	0.74560	0.87842	0.68148
100.0	1.20834	0.93743	1.16215	0.90159	1.10549	0.85763	1.03841	0.80560	0.96201	0.74632
110.0	1.27292	0.98753	1.24051	0.96238	1.19777	0.92922	1.14434	0.88777	1.08087	0.83854
120.0	1.34678	1.04482	1.33276	1.03395	1.30959	1.01597	1.27648	0.99029	1.23363	0.95705
130.0	1.42572	1.10606	1.43375	1.11230	1.43501	1.11327	1.42842	1.10816	1.41388	1.09688
140.0	1.50408	1.16686	1.53606	1.19167	1.56469	1.21388	1.58892	1.23268	1.60864	1.24798
150.0	1.57523	1.22206	1.63048	1.26492	1.68644	1.30833	1.74231	1.35168	1.79833	1.39514
160.0	1.63232	1.26634	1.70721	1.32445	1.78669	1.38611	1.87038	1.45104	1.95905	1.51982
170.0	1.66934	1.29507	1.75741	1.36339	1.85286	1.43744	1.95573	1.51724	2.06724	1.60375
180.0	1.68218	1.30502	1.77488	1.37694	1.87601	1.45540	1.98572	1.54051	2.10545	1.63340

M=3.1795

θ°	$\alpha=1^\circ$		$\alpha=2^\circ$		$\alpha=3^\circ$		$\alpha=4^\circ$		$\alpha=5^\circ$	
	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c
0.0	1.31961	0.95694	1.26437	0.91687	1.21218	0.87903	1.16320	0.84351	1.11673	0.80981
10.0	1.32034	0.95746	1.26540	0.91762	1.21309	0.87969	1.16354	0.84376	1.11602	0.80930
20.0	1.32251	0.95903	1.26857	0.91992	1.21598	0.88179	1.16484	0.84470	1.11437	0.80810
30.0	1.32611	0.96165	1.27397	0.92383	1.22124	0.88560	1.16791	0.84693	1.11318	0.80723
40.0	1.33113	0.96528	1.28178	0.92950	1.22944	0.89155	1.17398	0.85133	1.11454	0.80822
50.0	1.33750	0.96991	1.29219	0.93705	1.24129	0.90014	1.18451	0.85897	1.12095	0.81287
60.0	1.34516	0.97546	1.30534	0.94659	1.25745	0.91186	1.20100	0.87092	1.13500	0.82306
70.0	1.35398	0.98186	1.32128	0.95814	1.27846	0.92709	1.22477	0.88816	1.15906	0.84051
80.0	1.36379	0.98897	1.33991	0.97165	1.30459	0.94604	1.25675	0.91135	1.19498	0.86656
90.0	1.37434	0.99662	1.36095	0.98691	1.33575	0.96863	1.29729	0.94074	1.24383	0.90198
100.0	1.38535	1.00460	1.38391	1.00356	1.37137	0.99447	1.34598	0.97606	1.30564	0.94680
110.0	1.39646	1.01266	1.40805	1.02106	1.41039	1.02276	1.40154	1.01634	1.37909	1.00006
120.0	1.40729	1.02051	1.43244	1.03875	1.45122	1.05237	1.46169	1.05997	1.46134	1.05971
130.0	1.41742	1.02786	1.45598	1.05582	1.49183	1.08182	1.52325	1.10461	1.54792	1.12250
140.0	1.42642	1.03439	1.47747	1.07141	1.52984	1.10938	1.58228	1.14741	1.63292	1.18413
150.0	1.43391	1.03982	1.49573	1.08465	1.56278	1.13327	1.63442	1.18522	1.70945	1.23963
160.0	1.43952	1.04389	1.50966	1.09475	1.58830	1.15178	1.67541	1.21494	1.77051	1.28391
170.0	1.44301	1.04642	1.51840	1.10109	1.60447	1.16350	1.70163	1.23396	1.80995	1.31251
180.0	1.44419	1.04727	1.52138	1.10325	1.61001	1.16752	1.71066	1.24050	1.82360	1.32241

M = 3.1795

	$\alpha = 6°$		$\alpha = 7°$		$\alpha = 8°$		$\alpha = 9$		$\alpha = 10°$	
$\theta°$	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c
0.0	1.07290	0.77803	1.03147	0.74798	0.99224	0.71954	0.95542	0.69284	0.92032	0.66738
10.0	1.07066	0.77640	1.02720	0.74489	0.98547	0.71462	0.94562	0.68573	0.90701	0.65773
20.0	1.06469	0.77207	1.01553	0.73643	0.96674	0.70105	0.91849	0.66606	0.87019	0.63103
30.0	1.05717	0.76662	0.99964	0.72490	0.94055	0.68205	0.88018	0.63827	0.81819	0.59332
40.0	1.05130	0.76236	0.98412	0.71365	0.91325	0.66225	0.83920	0.60856	0.76216	0.55269
50.0	1.05087	0.76206	0.97433	0.70655	0.89193	0.64679	0.80465	0.58350	0.71340	0.51733
60.0	1.05979	0.76852	0.97561	0.70748	0.88350	0.64068	0.78497	0.56923	0.68172	0.49436
70.0	1.08165	0.78437	0.99291	0.72002	0.89418	0.64843	0.78744	0.57102	0.67507	0.48954
80.0	1.11943	0.81177	1.03041	0.74721	0.92932	0.67391	0.81836	0.59344	0.70028	0.50782
90.0	1.17517	0.85219	1.09132	0.79138	0.99339	0.72037	0.88341	0.64062	0.76402	0.55404
100.0	1.24963	0.90618	1.17746	0.85385	1.08962	0.79015	0.98754	0.71613	0.87316	0.63318
110.0	1.34181	0.97303	1.28865	0.93448	1.21918	0.88410	1.13399	0.82233	1.03380	0.74967
120.0	1.44856	1.05044	1.42182	1.03105	1.37984	1.00061	1.32231	0.95889	1.24849	0.90536
130.0	1.56415	1.13426	1.57027	1.13870	1.56440	1.13444	1.54569	1.12088	1.51213	1.09654
140.0	1.68037	1.21854	1.72326	1.24965	1.75964	1.27603	1.78872	1.29711	1.80781	1.31095
150.0	1.78708	1.29592	1.86665	1.35363	1.94665	1.41164	2.02701	1.46991	2.10516	1.52659
160.0	1.87349	1.35859	1.98463	1.43918	2.10313	1.52511	2.23003	1.61714	2.36352	1.71394
170.0	1.92990	1.39949	2.06247	1.49563	2.20757	1.60085	2.36723	1.71663	2.54044	1.84223
180.0	1.94952	1.41372	2.08969	1.51537	2.24430	1.62748	2.41579	1.75184	2.60348	1.88795

M = 3.8946

θ°	$\alpha = 1^\circ$ P/P_a	$\alpha = 1^\circ$ P/P_c	$\alpha = 2^\circ$ P/P_a	$\alpha = 2^\circ$ P/P_c	$\alpha = 3^\circ$ P/P_a	$\alpha = 3^\circ$ P/P_c	$\alpha = 4^\circ$ P/P_a	$\alpha = 4^\circ$ P/P_c	$\alpha = 5^\circ$ P/P_a	$\alpha = 5^\circ$ P/P_c
0.0	1.43616	0.94113	1.35038	0.88492	1.26752	0.83061	1.18795	0.77848	1.11171	0.72851
10.0	1.43727	0.94185	1.35200	0.88598	1.26900	0.83159	1.18866	0.77894	1.11095	0.72802
20.0	1.44057	0.94402	1.35691	0.88919	1.27366	0.83464	1.19115	0.78057	1.10936	0.72697
30.0	1.44606	0.94761	1.36527	0.89467	1.28204	0.84013	1.19657	0.78412	1.10885	0.72664
40.0	1.45368	0.95261	1.37732	0.90257	1.29496	0.84860	1.20662	0.79071	1.11232	0.72891
50.0	1.46337	0.95896	1.39332	0.91305	1.31338	0.86067	1.22335	0.80167	1.12324	0.73607
60.0	1.47500	0.96658	1.41345	0.92625	1.33829	0.87699	1.24892	0.81843	1.14526	0.75050
70.0	1.48838	0.97535	1.43779	0.94220	1.37045	0.89807	1.28526	0.84224	1.18185	0.77448
80.0	1.50324	0.98508	1.46620	0.96081	1.41032	0.92420	1.33387	0.87410	1.23590	0.80990
90.0	1.51922	0.99556	1.49826	0.98182	1.45782	0.95532	1.39545	0.91445	1.30940	0.85806
100.0	1.53589	1.00648	1.53323	1.00474	1.51220	0.99095	1.46967	0.96309	1.40295	0.91937
110.0	1.55272	1.01751	1.57005	1.02887	1.57193	1.03010	1.55485	1.01891	1.51526	0.99296
120.0	1.56912	1.02826	1.60730	1.05328	1.63468	1.07122	1.64778	1.07980	1.64259	1.07641
130.0	1.58446	1.03831	1.64332	1.07688	1.69737	1.11230	1.74368	1.14265	1.77842	1.16541
140.0	1.59810	1.04725	1.67627	1.09848	1.75632	1.15093	1.83639	1.20340	1.91349	1.25393
150.0	1.60944	1.05468	1.70432	1.11685	1.80762	1.18455	1.91889	1.25747	2.03652	1.33455
160.0	1.61796	1.06026	1.72575	1.13090	1.84750	1.21068	1.98415	1.30023	2.13557	1.39946
170.0	1.62325	1.06373	1.73921	1.13971	1.87283	1.22728	2.02607	1.32770	2.19999	1.44167
180.0	1.62504	1.06490	1.74379	1.14272	1.88152	1.23297	2.04054	1.33718	2.22235	1.45633

M = 3.8946

θ°	$\alpha=6^\circ$ P/P_a	P/P_c	$\alpha=7^\circ$ P/P_a	P/P_c	$\alpha=8^\circ$ P/P_a	P/P_c	$\alpha=9^\circ$ P/P_a	P/P_c	$\alpha=10^\circ$ P/P_a	P/P_c
0.0	1.03863	0.68062	0.96876	0.63484	0.90212	0.59117	0.83843	0.54943	0.77776	0.50967
10.0	1.03576	0.67874	0.96313	0.63115	0.89315	0.58529	0.82554	0.54099	0.76045	0.49833
20.0	1.02819	0.67378	0.94782	0.62112	0.86850	0.56914	0.79013	0.51778	0.71309	0.46729
30.0	1.01892	0.66771	0.92721	0.60761	0.83440	0.54679	0.74085	0.48549	0.64762	0.42439
40.0	1.01234	0.66339	0.90757	0.59474	0.79945	0.52388	0.68919	0.45163	0.57904	0.37945
50.0	1.01362	0.66424	0.89603	0.58717	0.77290	0.50649	0.64669	0.42378	0.52126	0.34159
60.0	1.02815	0.67376	0.89974	0.58960	0.76356	0.50036	0.62341	0.40853	0.48495	0.31779
70.0	1.06106	0.69532	0.92545	0.60645	0.77941	0.51075	0.62790	0.41147	0.47817	0.31335
80.0	1.11691	0.73192	0.97940	0.64181	0.82801	0.54260	0.66835	0.43798	0.50865	0.33332
90.0	1.19937	0.78596	1.06716	0.69932	0.91690	0.60085	0.75391	0.49404	0.58649	0.38433
100.0	1.31062	0.85886	1.19318	0.78190	1.05334	0.69026	0.89514	0.58659	0.72566	0.47553
110.0	1.45053	0.95054	1.35954	0.89092	1.24293	0.81450	1.10256	0.72252	0.94304	0.61798
120.0	1.61556	1.05869	1.56411	1.02498	1.48670	0.97424	1.38270	0.90609	1.25342	0.82137
130.0	1.79778	1.17810	1.79845	1.17854	1.77726	1.16465	1.73173	1.13482	1.66013	1.08789
140.0	1.98445	1.30043	2.04627	1.34094	2.09540	1.37313	2.12898	1.39514	2.14368	1.40477
150.0	2.15871	1.41462	2.28381	1.49660	2.40927	1.57882	2.53362	1.66030	2.65412	1.73927
160.0	2.30170	1.50832	2.48276	1.62697	2.67806	1.75495	2.88870	1.89299	3.11428	2.04081
170.0	2.39589	1.57005	2.61566	1.71406	2.86034	1.87440	3.13349	2.05340	3.43726	2.25247
180.0	2.42881	1.59162	2.66243	1.74471	2.92497	1.91675	3.22101	2.11075	3.55377	2.32882

M = 5.1033

θ°	$\alpha = 1^\circ$		$\alpha = 2^\circ$		$\alpha = 3^\circ$		$\alpha = 4^\circ$		$\alpha = 5^\circ$	
	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c	P/P_a	P/P_c
0.0	1.67141	0.91484	1.51911	0.83148	1.37247	0.75122	1.23209	0.67438	1.09867	0.60135
10.0	1.67335	0.91590	1.52201	0.83307	1.37533	0.75278	1.23389	0.67536	1.09847	0.60124
20.0	1.67914	0.91907	1.53081	0.83788	1.38417	0.75762	1.23984	0.67862	1.09880	0.60142
30.0	1.68876	0.92433	1.54575	0.84606	1.39980	0.76618	1.25156	0.68504	1.10232	0.60335
40.0	1.70210	0.93164	1.56716	0.85778	1.42344	0.77911	1.27152	0.69596	1.11308	0.60924
50.0	1.71904	0.94091	1.59543	0.87325	1.45656	0.79724	1.30274	0.71305	1.13601	0.62179
60.0	1.73934	0.95202	1.63083	0.89263	1.50065	0.82137	1.34852	0.73811	1.17652	0.64396
70.0	1.76267	0.96479	1.67345	0.91595	1.55701	0.85222	1.41204	0.77287	1.24008	0.67875
80.0	1.78856	0.97896	1.72306	0.94311	1.62645	0.89023	1.49595	0.81880	1.33182	0.72897
90.0	1.81640	0.99420	1.77898	0.97372	1.70899	0.93541	1.60191	0.87680	1.45596	0.79692
100.0	1.84542	1.01008	1.83999	1.00711	1.80360	0.98719	1.73002	0.94692	1.61499	0.88396
110.0	1.87472	1.02612	1.90430	1.04231	1.90792	1.04429	1.87817	1.02801	1.80845	0.98985
120.0	1.90328	1.04175	1.96949	1.07799	2.01809	1.10459	2.04147	1.11739	2.03153	1.11195
130.0	1.93001	1.05638	2.03269	1.11258	2.12882	1.16520	2.21190	1.21067	2.27388	1.24460
140.0	1.95378	1.06940	2.09066	1.14431	2.23361	1.22256	2.37852	1.30187	2.51914	1.37884
150.0	1.97357	1.08022	2.14012	1.17138	2.32532	1.27275	2.52830	1.38385	2.74605	1.50304
160.0	1.98843	1.08836	2.17800	1.19212	2.39696	1.31196	2.64775	1.44923	2.93103	1.60429
170.0	1.99765	1.09341	2.20182	1.20516	2.44261	1.33695	2.72494	1.49148	3.05238	1.67071
180.0	2.00078	1.09512	2.20995	1.20961	2.45829	1.34554	2.75165	1.50610	3.09469	1.69387

M = 5.1033

θ°	$\alpha = 6^{\circ}$ P/P_a	P/P_c	$\alpha = 7^{\circ}$ P/P_a	P/P_c	$\alpha = 8^{\circ}$ P/P_a	P/P_c	$\alpha = 9^{\circ}$ P/P_a	P/P_c	$\alpha = 10^{\circ}$ P/P_a	P/P_c
0.0	0.97289	0.53251	0.85494	0.46795	0.74483	0.40768	0.64344	0.35218	0.54972	0.30089
10.0	0.96986	0.53085	0.84841	0.46438	0.73430	0.40191	0.62860	0.34406	0.53049	0.29036
20.0	0.96219	0.52665	0.83093	0.45481	0.70572	0.38627	0.58840	0.32206	0.47896	0.26216
30.0	0.95390	0.52211	0.80823	0.44238	0.66717	0.36517	0.53402	0.29230	0.41048	0.22467
40.0	0.95089	0.52047	0.78844	0.43155	0.62939	0.34449	0.47940	0.26240	0.34270	0.18757
50.0	0.96020	0.52556	0.78069	0.42731	0.60351	0.33033	0.43733	0.23937	0.28954	0.15848
60.0	0.98938	0.54153	0.79432	0.43477	0.59989	0.32835	0.41806	0.22882	0.25958	0.14208
70.0	1.04619	0.57263	0.83882	0.45913	0.62866	0.34409	0.43061	0.23569	0.25873	0.14161
80.0	1.13844	0.62312	0.92436	0.50594	0.70121	0.38381	0.48594	0.26598	0.29531	0.16164
90.0	1.27367	0.69714	1.06202	0.58129	0.83190	0.45534	0.60044	0.32865	0.38575	0.21114
100.0	1.45817	0.79812	1.26327	0.69145	1.03835	0.56834	0.79812	0.43685	0.55945	0.30621
110.0	1.69514	0.92782	1.53752	0.84155	1.33906	0.73293	1.10925	0.60714	0.86010	0.47077
120.0	1.98200	1.08484	1.88769	1.03322	1.74703	0.95623	1.56251	0.85523	1.33807	0.73239
130.0	2.30744	1.26296	2.30443	1.26132	2.25976	1.23687	2.16953	1.18748	2.02906	1.11060
140.0	2.64944	1.45016	2.76097	1.51120	2.84851	1.55912	2.90522	1.59016	2.92120	1.59890
150.0	2.97586	1.62882	3.21189	1.75801	3.45277	1.88986	3.69371	2.02173	3.92583	2.14879
160.0	3.24843	1.77801	3.59843	1.96958	3.98604	2.18174	4.41239	2.41510	4.87515	2.66839
170.0	3.43017	1.87749	3.86076	2.11317	4.35506	2.38372	4.92042	2.69317	5.56212	3.04440
180.0	3.49406	1.91246	3.95381	2.16410	4.48723	2.45606	5.10432	2.79383	5.81367	3.18209

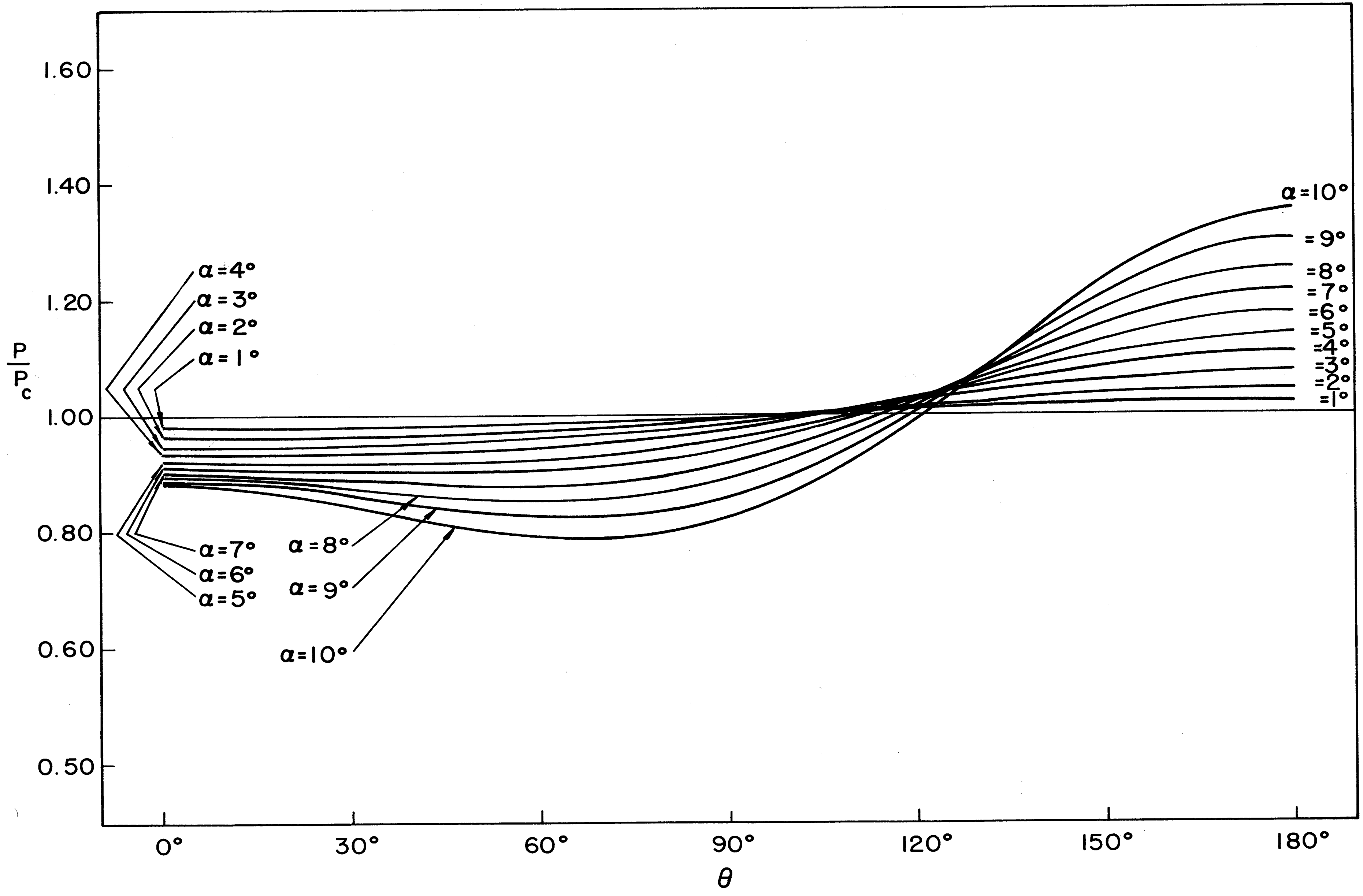
M = 8.0589

θ°	$\alpha = 1^\circ$ P/P_a	$\alpha = 1^\circ$ P/P_c	$\alpha = 2^\circ$ P/P_a	$\alpha = 2^\circ$ P/P_c	$\alpha = 3^\circ$ P/P_a	$\alpha = 3^\circ$ P/P_c	$\alpha = 4^\circ$ P/P_a	$\alpha = 4^\circ$ P/P_c	$\alpha = 5^\circ$ P/P_a	$\alpha = 5^\circ$ P/P_c
0.0	2.46313	0.86607	2.11520	0.74373	1.80582	0.63495	1.53219	0.53874	1.29375	0.45490
10.0	2.46803	0.86779	2.12278	0.74640	1.81409	0.63786	1.53949	0.54131	1.29882	0.45668
20.0	2.48270	0.87295	2.14565	0.75444	1.83933	0.64673	1.56222	0.54930	1.31525	0.46246
30.0	2.50699	0.88149	2.18420	0.76799	1.88285	0.66204	1.60280	0.56357	1.34664	0.47350
40.0	2.54067	0.89333	2.23898	0.78726	1.94668	0.68448	1.66507	0.58546	1.39872	0.49181
50.0	2.58331	0.90833	2.31058	0.81243	2.03334	0.71495	1.75405	0.61675	1.47906	0.52006
60.0	2.63432	0.92626	2.39939	0.84366	2.14556	0.75441	1.87556	0.65947	1.59684	0.56147
70.0	2.69282	0.94683	2.50542	0.88094	2.28578	0.80371	2.03577	0.71580	1.76249	0.61972
80.0	2.75762	0.96962	2.62800	0.92404	2.45570	0.86346	2.24038	0.78775	1.98700	0.69866
90.0	2.82720	0.99408	2.76550	0.97239	2.65547	0.93370	2.49362	0.87679	2.28071	0.80193
100.0	2.89966	1.01956	2.91506	1.02498	2.88304	1.01372	2.79666	0.98334	2.65107	0.93215
110.0	2.97278	1.04527	3.07246	1.08032	3.13335	1.10173	3.14591	1.10614	3.09942	1.08980
120.0	3.04402	1.07032	3.23203	1.13643	3.39777	1.19470	3.53121	1.24162	3.61704	1.27180
130.0	3.11069	1.09376	3.38682	1.19085	3.66403	1.28832	3.93468	1.38349	4.18174	1.47036
140.0	3.17002	1.11462	3.52900	1.24084	3.91669	1.37716	4.33083	1.52278	4.75626	1.67237
150.0	3.21938	1.13198	3.65046	1.28355	4.13847	1.45514	4.68851	1.64855	5.29045	1.86019
160.0	3.25649	1.14503	3.74362	1.31631	4.31216	1.51622	4.97480	1.74921	5.72775	2.01396
170.0	3.27952	1.15313	3.80226	1.33693	4.42305	1.55521	5.16031	1.81443	6.01546	2.11512
180.0	3.28733	1.15587	3.82228	1.34397	4.46119	1.56862	5.22459	1.83704	6.11592	2.15044

M = 8.0589

θ°	α = 6° P/P_a	α = 6° P/P_c	α = 7° P/P_a	α = 7° P/P_c	α = 8° P/P_a	α = 8° P/P_c	α = 9° P/P_a	α = 9° P/P_c	α = 10° P/P_a	α = 10° P/P_c
0.0	1.08842	0.38270	0.91492	0.32170	0.76819	0.27011	0.64600	0.22714	0.54500	0.19163
10.0	1.09033	0.38338	0.91313	0.32107	0.76237	0.26806	0.63609	0.22366	0.53108	0.18673
20.0	1.09774	0.38598	0.90993	0.31994	0.74771	0.26291	0.61007	0.21451	0.49423	0.17378
30.0	1.11546	0.39221	0.91147	0.32048	0.73199	0.25738	0.57775	0.20315	0.44699	0.15717
40.0	1.15105	0.40473	0.92706	0.32597	0.72630	0.25538	0.55215	0.19414	0.40458	0.14226
50.0	1.21448	0.42703	0.96856	0.34056	0.74384	0.26154	0.54719	0.19240	0.38110	0.13400
60.0	1.31795	0.46341	1.05038	0.36933	0.80003	0.28130	0.57784	0.20318	0.38954	0.13697
70.0	1.47604	0.51900	1.19032	0.41853	0.91432	0.32149	0.66307	0.23314	0.44611	0.15686
80.0	1.70560	0.59971	1.41063	0.49600	1.11305	0.39136	0.83099	0.29219	0.57787	0.20319
90.0	2.02488	0.71197	1.73833	0.61122	1.43193	0.50349	1.12449	0.39539	0.83215	0.29260
100.0	2.45088	0.86176	2.20299	0.77460	1.91551	0.67352	1.60402	0.56400	1.28462	0.45169
110.0	2.99452	1.05291	2.83038	0.99520	2.61042	0.91786	2.34231	0.82359	2.03836	0.71671
120.0	3.65346	1.28461	3.63136	1.27684	3.54965	1.24811	3.40467	1.19713	3.20232	1.12598
130.0	4.40439	1.54864	4.58746	1.61301	4.72878	1.66271	4.81332	1.69243	4.84172	1.70242
140.0	5.19774	1.82760	5.63850	1.98257	6.08162	2.13838	6.50479	2.28717	6.90959	2.42951
150.0	5.95860	2.09513	6.67961	2.34864	7.46850	2.62603	8.30250	2.91927	9.19284	3.23233
160.0	6.59637	2.31937	7.57391	2.66309	8.69089	3.05584	9.92973	3.49143	11.31771	3.97946
170.0	7.02269	2.46928	8.18160	2.87676	9.53583	3.35293	11.07425	3.89389	12.83956	4.51456
180.0	7.17276	2.52204	8.39727	2.95260	9.83827	3.45927	11.48763	4.03921	13.39392	4.70949

YAWED TO NON-YAWED PRESSURE RATIO P/P_c M=2.0108



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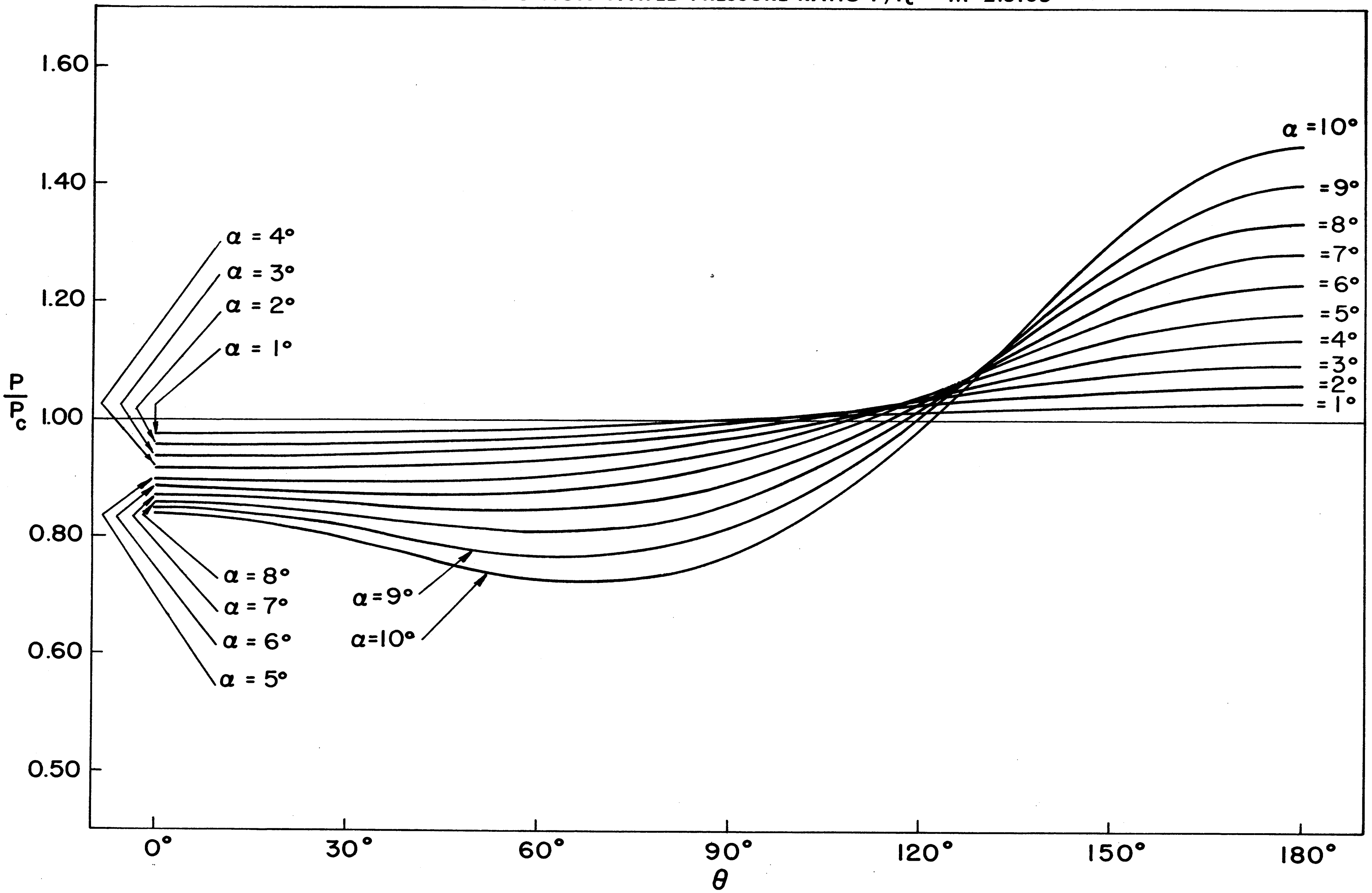

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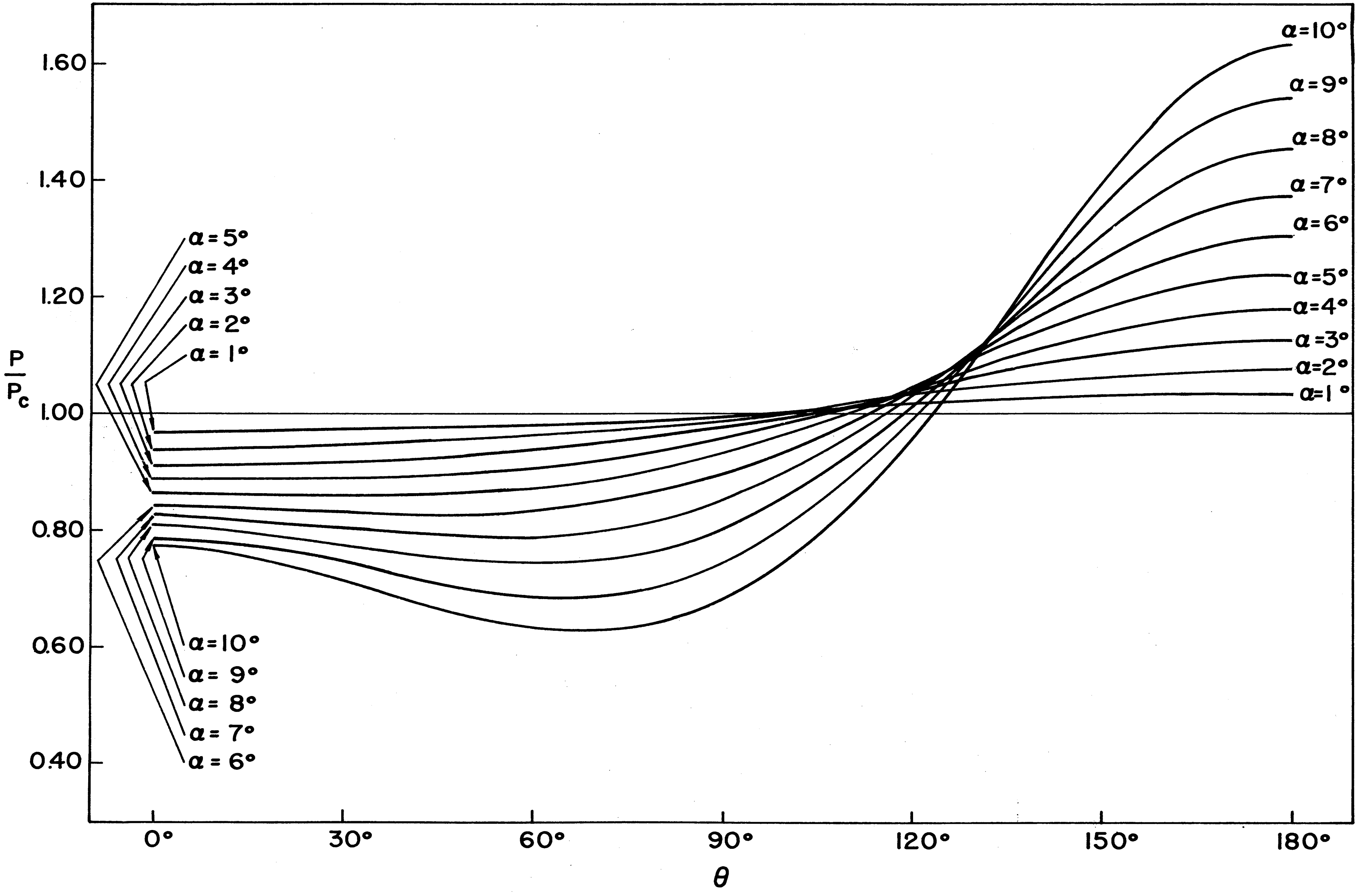

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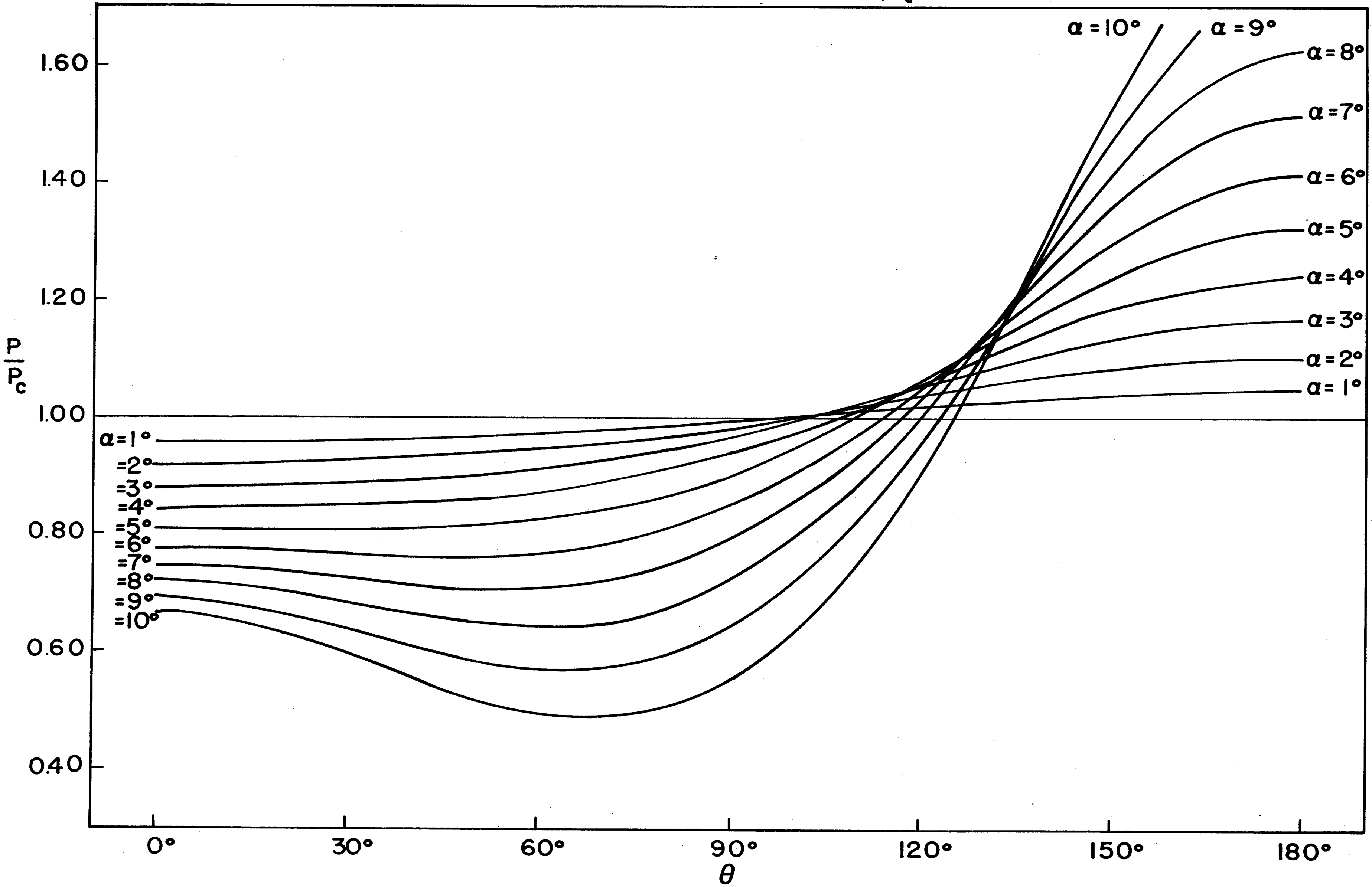

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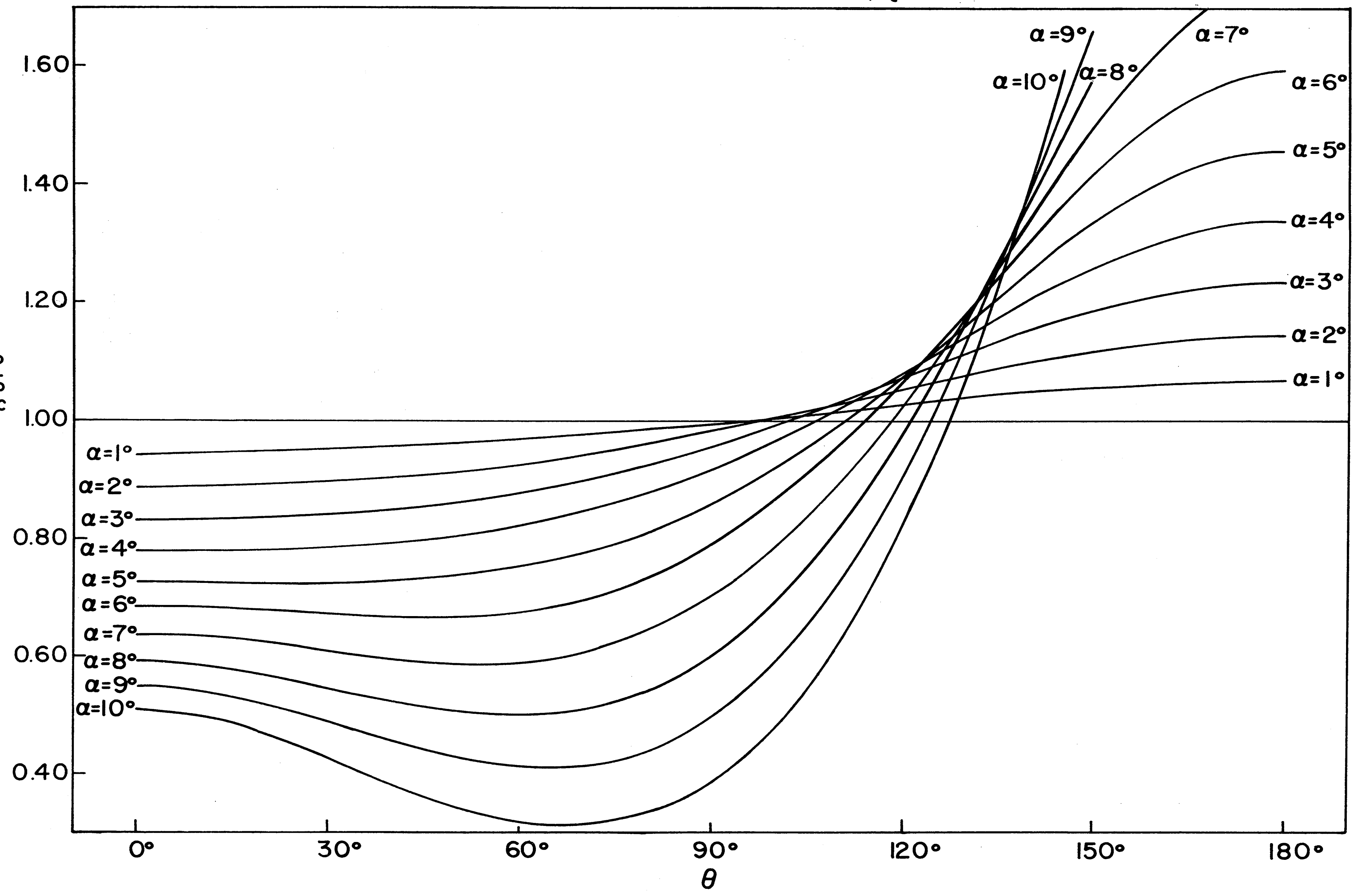

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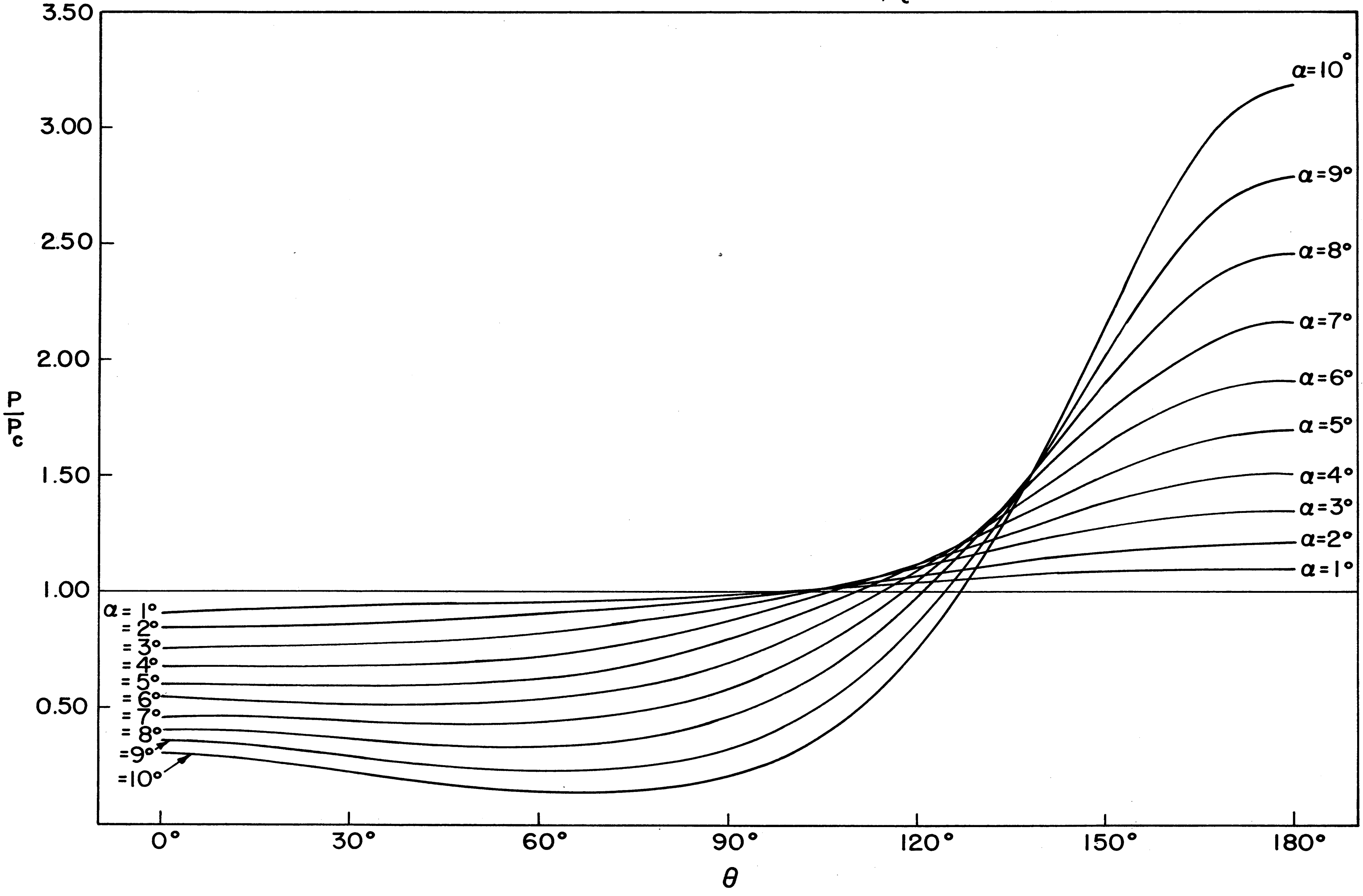

YAWED TO NON-YAWED PRESSURE RATIO P/Pc   M=8.0589