

ESDU Bodies S.05.03.01

PRESSURE DISTRIBUTION ON FOREBODIES AND AFTERBODIES OF REVOLUTION AT ZERO INCIDENCE IN INVISCID FLOW

1. NOTATION AND UNITS (see Figures 1 to 3)

		SI	British
c_p	static pressure coefficient at point on body surface defined by coordinate x , $(p - p_0)/\frac{1}{2}\gamma p_0 M_0^2$		
L	length of pointed parabolic afterbody, $l_a[R_1/(R_1 - R_0)]^{1/2}$, or length of pointed conical afterbody, $l_a R_1/(R_1 - R_0)$	m	ft
l_a	length of boat-tailed afterbody	m	ft
l_f	length of forebody	m	ft
M_0	free-stream Mach number		
p	static pressure at point on body surface defined by coordinate x	N/m ²	lbf/ft ²
p_0	free-stream static pressure	N/m ²	lbf/ft ²
R_0	radius of base of afterbody	m	ft
R_1	radius of maximum cross-section of body	m	ft
x	axial coordinate of point on body surface, measured aft from nose of forebody or from junction of midbody and afterbody	m	ft
γ	ratio of specific heat capacity at constant pressure to specific heat capacity at constant volume, assumed equal to 1.4 for air		

2. NOTES

2.1 Presentation of Data

Figure 1 gives the pressure distribution on the surface of tangent ogive forebodies and Figures 2 and 3 give the pressure distribution on parabolic and conical afterbodies, at zero incidence and in inviscid flow. The curves shown have been obtained by the application of the supersonic-hypersonic similarity law (see Item No. Aero B.S.02.03.01) to the results of calculations for pressure distributions given in Derivations 1 to 4 (see Section 2.2).

The curves in Figure 1 were calculated for forebodies of revolution generated by a circular arc tangential to the midbody, but, to the order of accuracy of the theory, the results may also be applied to pointed parabolic arc forebodies which are tangential to the midbody at their junction. It should be noted that the curves can also be used for secant ogive forebodies in which there is a discontinuity of surface at the junction of the forebody and midbody. In this case, however, the values of l_f and R_1 to be used in the parameters on Figure 1 are those of the corresponding tangent ogive forebody, this forebody being generated by an arc

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of the same circle (or parabola) as the secant ogive forebody (see sketch on Figure 1). The pressure distribution on conical forebodies corresponds to the pressure on a surface behind a conical shock wave and is given by exact theory in Item No. Aero S.00.03.13.

The curves in Figure 2 were calculated for afterbodies of revolution generated by parabolic arcs which are tangential to the midbody at their junction. To the order of accuracy of the theory, the curves may also be applied to circular arc afterbodies which are tangential to the midbody at their junction. All the curves in Figures 2 and 3 were derived for afterbodies preceded by a midbody of sufficient length to give uniform flow, at the free-stream Mach number, at the beginning of the afterbodies. For afterbodies behind a short midbody, slender-body theory indicates that the pressure distribution may be obtained by adding the pressure coefficient on an afterbody behind a long midbody to that which would exist at the axial station in question on the actual midbody if it were extended into the region of the afterbody.

2.2 Sources of Pressure Distributions

Derivation 1 gives pressure distribution results for tangent ogive forebodies obtained by using the method of characteristics, allowance being made for the effects of vorticity introduced by the nose shock wave. In Figure 1 slender-body theory has been used to extend these results from a value of $(M^2 - 1)^{1/2} R_1/l_f$ of 0.2 down to a value of 0.1.

Derivations 2 and 3 give pressure distribution results for parabolic afterbodies obtained by using the method of characteristics.

Derivation 4 gives pressure distribution results for conical afterbodies obtained by using van Dyke's second-order theory.

3. DERIVATION

The Derivation lists selected sources that have assisted in the preparation of this Item.

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| 1. | ROSSOW, V.J. | Applicability of the hypersonic similarity rule to pressure distributions which include the effects of rotation for bodies of revolution at zero angle of attack. NACA tech. Note 2399, 1951. |
| 2. | VAN DYKE, M.D. | Practical calculation of the second order supersonic flow past non-lifting bodies of revolution. NACA tech. Note 2744, 1952. |
| 3. | FRAENKEL, L.E. | Calculations of the pressure distributions and boundary layer development on a body of revolution with various parabolic afterbodies at supersonic speeds. RAE Rep. aero. 2482, 1953. |
| 4. | JACK, J.R. | Theoretical pressure distribution and wave drags for conical boattails. NACA tech. Note 2972, 1953. |