

NACA 1-SERIES GEOMETRY REPRESENTATION FOR COMPUTATIONAL FLUID DYNAMICS

1. NOTATION AND DEFINITIONS

1.1 Notation

A_n, b, c	coefficients in Equation (4.1)
C_p	pressure coefficient
CR	contraction ratio, $(D_1/D_{throat})^2$
D_{max}	maximum diameter of forecowl
D_{throat}	throat diameter
D_1	highlight diameter of forecowl
d	minimum internal diameter of original NACA 1-Series forecowl, see Definitions
L_f	length of forecowl
M_∞	freestream Mach number
mfr	mass flow ratio
n	integer, see Equation (4.1)
r	internal lip radius of original NACA 1-Series forecowl, see Definitions
X	normalising length for forecowl longitudinal coordinate, see Definitions
x	forecowl longitudinal coordinate with origin at highlight
Y	normalising length for forecowl radial coordinate, see Definitions
y	forecowl radial coordinate with origin at highlight
ρ	radius of curvature of forecowl external profile at highlight
Suffix	
i	integer denoting member of set of coordinates

1.2 Definition of NACA 1-Series Forecowl External Profile

100 x/X	100 y/Y	100 x/X	100 y/Y	100 x/X	100 y/Y	100 x/X	100 y/Y	100 x/X	100 y/Y
0	0	9.0	34.03	26.0	60.35	43.0	77.32	70.0	93.95
0.2	4.80	10.0	36.13	27.0	61.52	44.0	78.15	72.0	94.75
0.4	6.63	11.0	38.15	28.0	62.67	45.0	78.95	74.0	95.48
0.6	8.12	12.0	40.09	29.0	63.79	46.0	79.74	76.0	96.16
0.8	9.33	13.0	41.94	30.0	64.89	47.0	80.50	78.0	96.79
1.0	10.38	14.0	43.66	31.0	65.97	48.0	81.25	80.0	97.35
1.5	12.72	15.0	45.30	32.0	67.03	49.0	81.99	82.0	97.87
2.0	14.72	16.0	46.88	33.0	68.07	50.0	82.69	84.0	98.33
2.5	16.57	17.0	48.40	34.0	69.08	52.0	84.10	86.0	98.74
3.0	18.31	18.0	49.88	35.0	70.08	54.0	85.45	88.0	99.09
3.5	19.94	19.0	51.31	36.0	71.05	56.0	86.73	90.0	99.40
4.0	21.48	20.0	52.70	37.0	72.00	58.0	87.95	92.0	99.65
4.5	22.96	21.0	54.05	38.0	72.94	60.0	89.11	94.0	99.85
5.0	24.36	22.0	55.37	39.0	73.85	62.0	90.20	96.0	99.93
6.0	27.01	23.0	56.66	40.0	74.75	64.0	91.23	98.0	99.98
7.0	29.47	24.0	57.92	41.0	75.63	66.0	92.20	100.0	100.00
8.0	31.81	25.0	59.15	42.0	76.48	68.0	93.11		

1.3 Definition of Internal Geometry

- (a) **Original NACA 1-Series lip:** quarter circle from highlight with radius[†], $r = 0.025 Y$, followed by constant diameter, d , duct.
- (b) **All other cases:** Internal lip, throat and diffuser chosen to suit application – see Section 3.2.

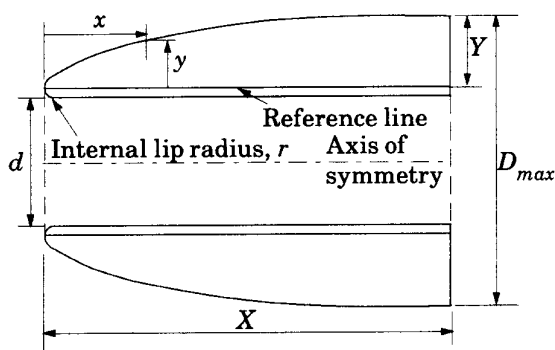
[†] In general, the internal lip radius, r , defined here does not equal the radius of curvature, ρ , of the external profile at the highlight – see Section 3.1.1

1.4 Definition of Normalising Dimensions X , Y

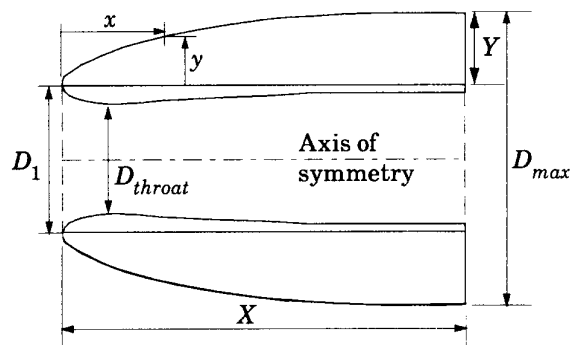
In all cases $X = L_f$, i.e. forecowl length.

$$(a) \quad Y = \frac{D_{max} - d}{2} - r = \frac{D_{max} - d}{2.05}$$

$$(b) \quad Y = \frac{D_{max} - D_1}{2}$$



(a) **Original NACA 1-Series profile (Ref. 1)**



(b) **NACA 1-Series external profile with realistic internal geometry**

Sketch 1.1 Illustrations of forecowl profile and notation

2. INTRODUCTION

The definition of the NACA 1-Series forecowl profile is presented together with deductions and modifications. The material is general in application but has been prepared in conjunction with the wave drag and pressure coefficient data of References 2 and 3.

The NACA 1-Series forecowl profile is defined originally in Reference 1, which reports investigations into “high critical speed” intakes. Subsequently, the (external) profile has acquired widespread acceptance as a “standard” and is often used as a starting point, at least, for investigating flow characteristics of axisymmetric forecows. The Definitions Sections 1.2 to 1.4 and Sketch 1.1 present the coordinates of the NACA 1-Series forecowl external profile together with both the original and a more realistic treatment of the internal profile.

3. DEDUCTIONS FROM AND MODIFICATIONS TO NACA 1-SERIES FORECOWL PROFILE

3.1 External Profile

3.1.1 Highlight radius of curvature

The radius of curvature, ρ , of the NACA 1-Series external profile, at the highlight, is given by

$$\frac{\rho}{D_1} = \frac{0.1365 \left(1 - \frac{D_1}{D_{max}} \right)^2}{\frac{L_f}{D_{max}} \frac{D_1}{D_{max}}} \quad (3.1)$$

Equation (3.1) is taken from Reference 4 and provides a close approximation to ρ on the basis of the first few coordinates in Section 1.2.

3.1.2 Simple curve fit to NACA 1-Series external profile

One example of a simple analytical approximation to the NACA 1-Series external profile is

$$\left(\frac{y}{Y} \right) = \left\{ \sin \left[\frac{\pi}{2} \left(\frac{x}{X} \right) \right] \right\}^{0.55} \quad (3.2)$$

Equation (3.2) represents the coordinates given in Section 1.2 to within about 0.6% of Y . This was not considered adequate for flow computations presented in References 2 and 3 – see Section 4.

3.2 Selection of Realistic Internal Profile

The original internal lip of the NACA 1-Series forecowl is defined in Section 1.3(a) but has found little practical use. For design purposes a revised internal profile is selected which, ideally, would

- (i) accept the engine airflow at all operating conditions,
- (ii) give a low value of pressure loss at all operating conditions – in particular by avoidance of shock formation or boundary layer separation,