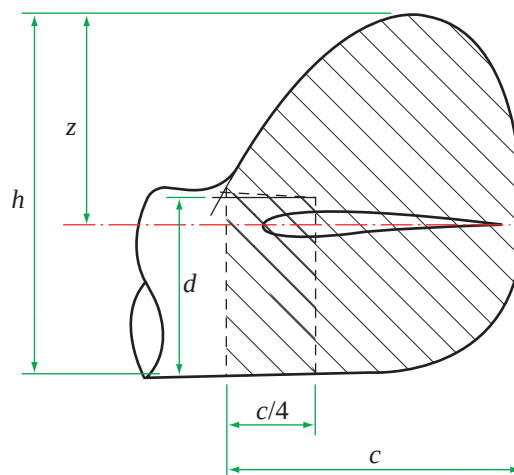


# ESDU Controls 01.01.01

## LIFT-CURVE SLOPE FOR SINGLE FIN AND RUDDER (i) BODY SHAPE MERGING INTO FIN

### 1. NOTATION AND UNITS

|        |                                                                                                                        | SI                   | British              |
|--------|------------------------------------------------------------------------------------------------------------------------|----------------------|----------------------|
| $A$    | aspect ratio of fin and rudder, $h^2/S'$                                                                               |                      |                      |
| $A_E$  | equivalent aspect ratio of fin and rudder, allowing for end plate effect of tailplane                                  |                      |                      |
| $a_1$  | lift-curve slope of fin and rudder, based on $S'$ , considered as wing of rectangular planform with aspect ratio $A_E$ | radian <sup>-1</sup> | radian <sup>-1</sup> |
| $a'_1$ | lift-curve slope of fin and rudder, based on $S'$ , allowing for wing, body and tailplane effects                      | radian <sup>-1</sup> | radian <sup>-1</sup> |
| $c$    | maximum chord length of fin and rudder (see Sketch 1.1)                                                                | m                    | ft                   |
| $d$    | body depth at $c/4$ aft of leading edge of $c$ (see Sketch 1.1)                                                        | m                    | ft                   |
| $h$    | overall height of fin and rudder (see Sketch 1.1)                                                                      | m                    | ft                   |
| $S'$   | effective area of fin and rudder, including body contribution (see Sketch 1.1)                                         | m <sup>2</sup>       | ft <sup>2</sup>      |
| $z$    | distance from tailplane chord line to top of fin and rudder (see Sketch 1.1)                                           | m                    | ft                   |
| $\tau$ | trailing-edge angle of fin and rudder aerofoil section                                                                 | degree               | degree               |



Sketch 1.1

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## 2. NOTES

This Item gives the lift-curve slope for a single fin and rudder of the type shown in Sketch 1.1. Similar data for a single fin and rudder mounted on a body of circular cross-section are given in Item No. 82010. For twin fins and rudders see Item No. Aero C.01.01.02.

The fin and rudder are considered as equivalent to a wing of rectangular planform having an equivalent aspect ratio  $A_E$  which allows for the end plate effect of the tailplane. The ratio  $A_E/A$  is given in Figure 1 in terms of the tailplane position on the fin and rudder. Figure 2 gives the lift-curve slope,  $a_1$ , for a wing of rectangular planform in terms of  $A_E$  and  $\tau$ , the trailing-edge angle of the rudder aerofoil section. It should be noted that this value of  $a_1$  does not correspond exactly to that which would be found by using Item No. Aero W.01.01.01 but is included here since it was used in the original analysis of the fin and rudder data. Figure 3 gives the ratio  $a'_1/a_1$  in terms of  $d/h$ .

In addition to the effects of the body and the tailplane position on the airflow over the fin and rudder, there is also an effect due to the wing position on the body. Experimental evidence indicates that values for the effect of wing position on the body lie within the hatched area shown on Figure 3. There is a tendency for data from low-wing configurations to lie above the mean line and for those from high-wing configurations to lie below the mean line.

If there is a gap between the rudder and the fin allowance may be made for its effect by using Item No. Aero C.01.01.04. It is known that dorsal fins cause large alterations to the values of  $a'_1$  given by the present Item, but existing information is too scanty for reliable prediction.

The curves have been obtained (Derivation 1) from data from wind-tunnel tests in the absence of slipstream effects and it is estimated that the accuracy is within  $\pm 10$  per cent.

The centre of pressure position of the sideforce may be approximated by considering the parts of the sideforce acting on the fin above and below the tailplane separately and assuming a half-wing elliptical spanwise loading over the fin extent to either side of the tailplane. This gives a vertical location for each part of the sideforce which is at 40 per cent of the fin extent to either side of the tailplane and located on the fin quarter-chord line. The overall centre of pressure position is obtained by assuming that the magnitudes of the fin loads above and below the tailplane are in the same ratio as the fin areas above and below the tailplane, and by taking moments about the required moment reference centre.

## 3. DERIVATION

1. LYONS, D.J.  
BISGOOD, P.L. An analysis of the lift slope of aerofoils of small aspect ratio, including fins, with design charts for aerofoils and control surfaces. ARC R & M 2308, 1950.