Transonics

1. The buffet on a transonic wing is usually associated with separation originating near:

a) the suction peak or the shock wave on the upper surface
b) the suction peak on the upper surface or the cove area on the lower surface
c) the shock wave or the trailing edge on the upper surface.

Hint: See ESDU 81020

Answer: (c). ESDU 81020 classifies the separations associated with buffet and gives a method to predict the separation boundary in terms of lift coefficient and Mach number. ESDU 91021, gives further information on determining the separation boundary for both aerofoils and wings.

2. The drag magnification factor, m_d, for an excrescence on an aerofoil is defined as the total drag penalty, ΔC_D, due to the excrescence, divided by the drag coefficient of the isolated excrescence, $(\Delta C_D)_0$. The drag magnification factor, m_d, takes into account both the difference between the freestream and the local kinetic pressure at the excrescence and the effect of the excrescence on the flow around the aerofoil. ΔC_D and $(\Delta C_D)_0$ are based on:

a) ΔC_D: aerofoil chord and freestream kinetic pressure, $(\Delta C_D)_0$: aerofoil chord and local kinetic pressure
b) ΔC_D: aerofoil chord and freestream kinetic pressure, $(\Delta C_D)_0$: excrescence height and local kinetic pressure
c) ΔC_D: excrescence height and freestream kinetic pressure, $(\Delta C_D)_0$: excrescence height and freestream kinetic pressure.

Hint: See ESDU 87004

Answer: (a). ESDU 87004 gives three methods for the estimation of m_d to take into account both local flow conditions due to the basic aerofoil flow and changes in the flow caused by the excrescence.

3. For an RAE 2822 aerofoil operating at a Mach number of 0.675, a Reynolds number of 20×10^6 and a lift coefficient of 0.9, the drag magnification factor, m_d, for an excrescence at 20% chord on the upper surface is:

a) 0.983
b) 5.610
c) 2.132

Hint: See ESDU 87004

Answer: (b). ESDU 87004 presents this case as an example (Table 8.2). Three alternative calculation methods are given in the Data Item.

4. Running 'VGK for Windows' (ESDU 03015) for an RAE 5225 aerofoil at a specified lift coefficient with Mach number = 0.75, Reynolds number = 20 million and transition set at 5% chord on both upper and lower surfaces gives an incidence of:

a) 1.893 degrees
b) 0.246 degrees
c) 3.267 degrees

Hint: See ESDU 03015

Answer: (a). ESDU 03015 describes how to run VGK for Windows in viscous mode with a specified lift coefficient. Results are summarised in a pop-up window and files saved which give a more detailed analysis. In this example default calculation parameters can be used.

5. The VGK calculation of question 4 shows an upper-surface shock wave located at:

a) between 58% and 61% chord
b) there is no shock wave
c) between 65% and 68% chord

Hint: See ESDU 03015

Answer: (a) VGK for Windows (ESDU03015) allows quick plotting of the surface pressure distribution *via* the 'Results' menu. This quickly shows the location of any shock wave.

6. Adding vertical winglet having a length of 15% wingspan would be likely, for an elliptically loaded wing, to increase the lift/drag ratio for a typical transport aircraft by:

a) 15% to 20%
b) 4% to 5%
c) 7% to 9%

Hint: See ESDU 98013

Answer: (b). ESDU 98013 gives practical guidance on when to use winglets and how to size and design them. It can be used in conjunction with ESDU 97017 which provides a detailed guide to wing aerodynamic design procedures.

7. The VFP CFD method computes the flow around a wing-body combination using:

a) the Euler method
b) the RANS method
c) the full-potential method.

Hint: See ESDU 02013

Answer: (c). ESDU 02013 describes the principles of the VFP method and compares its results against known cases. ESDU 02014 gives instruction in the use of the program, which is of high accuracy and sufficiently economical to allow repetitive runs on a standard PC. Other data Items in the Section give detailed guidance on body representation and drag calculation, while ESDU 11007 shows how the inviscid method may be coupled with a frozen-boundary-layer method.

8. Sub-boundary-layer counter-rotating vortex generators were selected to reduce cabin noise in the Gulfstream III aircraft. The use of co-rotating generators of a similar size would probably:

a) increase the maximum effectiveness and improve downstream persistence
b) decrease the maximum effectiveness and improve downstream persistence
c) increase the maximum effectiveness and decrease downstream persistence

Hint: See ESDU 93026

Answer: (b). ESDU 93026 gives examples of the practical application of vortex generators to aircraft. ESDU 93024 and ESDU 93025 give guidance on the aerodynamic principles and design of vortex generators for controlling shock-induced separation.

9. Acenaphthene is used to:

a) show boundary layer transition in low-speed tests by evaporation
b) show boundary layer transition in high-speed tests by sublimation
c) show flow direction near the model surface by streaking

Hint: See ESDU 03014

Answer: (b). ESDU 03014 gives a comprehensive guide to flow-visualisation techniques and their interpretation. Pictures, unavailable elsewhere, are included from a large number of commercial tests.

10. For a transonic wind-tunnel test at low Reynolds number on a typical transport aircraft configuration transition on the wing is “aft fixed”, using a narrow band of artificial roughness, to:

a) match the transition location anticipated at full scale and prevent possible early separation just downstream of the wing leading edge
b) match the wing wake to full-scale conditions
c) match the boundary layer state at full scale either at the shock-wave location or near the trailing edge.

Hint: See ESDU 05022, 07010, 09015, 10006, 09016

Answer: (c). ESDU 05022, ESDU 07010, ESDU 09015and ESDU 10006 give a full description of the problems and techniques involved in scaling wind tunnel tests, particularly in the transonic range. ESDU 09016 gives a method to calculate the roughness height required to achieve transition in a “transition strip”.