B1

AVIATION MAINTENANCE TECHNICIAN CERTIFICATION SERIES

TURBINE AEROPLANE
STRUCTURES AND SYSTEMS

11

EASA 2023-989 COMPLIANT

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VERSION	EFFECTIVE DATE	DESCRIPTION OF REVISION(S)
001	2015.01	Module creation and release.
002	2016.01	Minor Revisions
003	2017.09	Format Updates
003.1	2019.02	Added section on Pneumatic and Pressure Pumps in Submodule 16.
003.2	2019.05	Corrected incorrect answers in Submodule 20.
004	2019.12	Typographic format updated; Sequencing of content to Appendix 1 refined.
004.1	2021.04	Enhanced content of M11A Submodule 08(b).
004.2	2023.01	Added Measurement Standards. Improved Figures 13-51, 18-5, and 18-6.
004.3	2023.04	Enhanced content in Submodule 14 - Lights.
005	2024.04	Regulatory update for EASA 2023-989 Compliance.

Module was reorganized based upon the EASA 2023-989 subject criteria. Enhancements included in this version 005 are:

11.1 *Drag Inducing Devices* - complete rewrite.
11.2 *Fuselage Components, Structural Assembly Techniques, Reinforcement* - added content.
11.3.1(B) *Airborne Towing Devices* - added content.
11.3.5 *Engine Mounts* - complete rewrite.
11.4(C) *Control and Indication Control Valves* - added content.
11.5.2 *Controller Pilot Datalink* - added content.
11.5.2 *Audio Systems* - added content.
11.5.2 *Cockpit Voice Recorders* - added content.
11.5.2 *Microwave Landing Systems* - added content.
11.5.2 *ARINC Communications* - added content.
11.5.2 *Avionics Test Equipment* - added content from Module 7.4.
11.6 *Battery Maintenance and Troubleshooting* - added content.
11.10 *Inert Gas Systems* - added content.
11.11 *Servicing Hydraulic Systems* - added content.
11.11 *Boeing 737NG Hydraulic System* - added content.
11.13 *Tail Protection and Tail Skids* - added content.
11.16 *Pneumatic System Components* - added content.
11.21 *Electronic Flight Bag Classifications* - added content.
Question and Answer updates for all Submodules.

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in maintaining the flight control surface in the desired position. Through linkage set from the cockpit, the tab can be positioned so that it is actually holding the control surface in position rather than the pilot. Therefore, elevator tabs are used to maintain the speed of the aircraft since they assist in maintaining the selected pitch. Rudder tabs can be set to hold yaw in check and maintain heading. Aileron tabs can help keep the wings level.

Occasionally, a simple light aircraft may have a stationary metal plate attached to the trailing edge of a primary flight control, usually the rudder. This is also a trim tab as shown in **Figure 1-27**. It can be bent slightly on the ground to trim the aircraft in flight to a hands off condition when flying straight and level. The correct amount of bend can be determined only by flying the aircraft after an adjustment. Note that a small amount of bending is usually sufficient.

SERVO TABS
A servo tab is similar to a balance tab in location and effect, but it is designed to operate the primary flight control surface, not just reduce the force needed to do so. It is usually used as a means to back up the primary control of the flight control surfaces. [**Figure 1-28**]

On heavy aircraft, large control surfaces require too much force to be moved manually and are usually deflected out of the neutral position by hydraulic actuators. These power control units are signaled via a system of hydraulic valves connected to the yoke and rudder pedals. On fly by wire aircraft, the hydraulic actuators that move the flight control surfaces are signaled by electric input. In the case of hydraulic system failure(s), manual linkage to a servo tab can be used to deflect it. This, in turn, provides an aerodynamic force that moves the primary control surface.

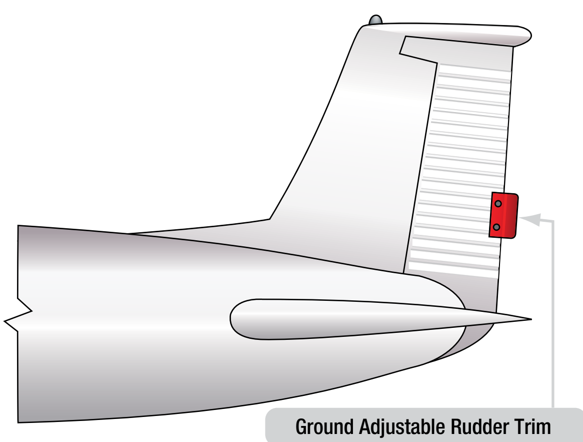

Figure 1-27. Example of a trim tab.

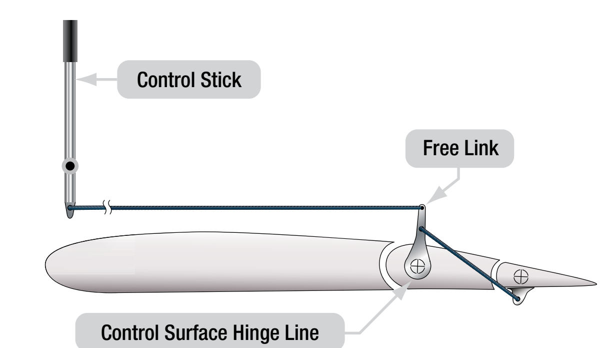

Figure 1-28. Servo tabs can be used to position flight control surfaces in case of hydraulic failure.

CONTROL SURFACE BIAS
When a control surface is in the neutral position, is faired with the wing rudder or horizontal stabilizer and no effect on the aircrafts aerodynamic surfaces. Some aircraft are designed with control surface bias.

This means that a control surface is not naturally in the neutral position. It is designed to impart a force on the airfoil at all times. The force is generally used to counter balance a design imbalance and alter the aircraft's aerodynamics for easy hands off flight. This means that when the aircraft is flying straight and level, the control surface bias has effect but all trim position gauges on the flight deck indicate zero trim.

SECTION B

AEROPLANE: OTHER AERODYNAMIC DEVICES

OPERATION AND EFFECTS

BALANCE TABS
The aerodynamic phenomenon of moving a trim tab in one direction to cause the control surface to experience a force moving in the opposite direction is exactly what occurs with the use of balance tabs. [**Figure 1-29**] Often, it is difficult to move a primary control surface due to its surface area and the speed of the air rushing over it. Deflecting a balance tab hinged at the trailing edge of the control surface in the opposite direction of the desired control surface movement causes a force to position the surface in the proper direction with reduced force to do so. Balance tabs are usually linked directly to the control surface linkage so that they move automatically when there is an input for control surface movement. They also can double as trim tabs if adjustable on the flight deck.

ANTI-SERVO/ANTI-BALANCE TABS
Anti-servo tabs, as the name suggests, are like servo tabs but move in the same direction as the primary control surface. On some

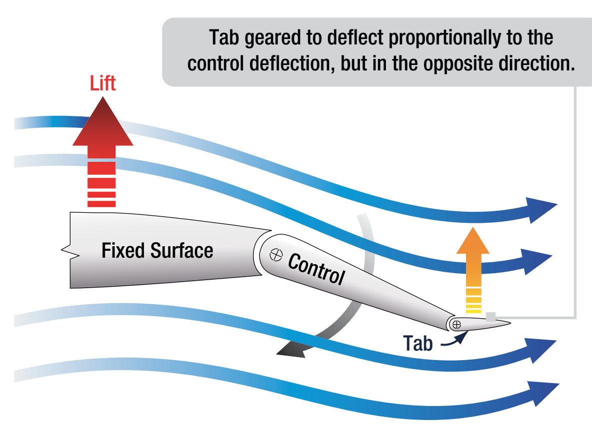

Figure 1-29. Balance tabs assist with forces needed to position control surfaces.

aircraft, especially those with a movable horizontal stabilizer, the input to the control surface can be too sensitive. An Anti-servo tab tied through the control linkage creates an aerodynamic force that increases the effort needed to move the control surface. This makes flying the aircraft more stable for the pilot. **Figure 1-30** shows an Anti-servo tab in the near neutral position. Deflected in the same direction as the desired stabilator movement, it increases the required control surface input. Anti-servo tabs are also known as anti-balance tabs.

SPRING TABS
A control surface may require excessive force to move only in the final stages of travel. When this is the case, a spring tab can be used. This is essentially a servo tab that does not activate until an effort is made to move the control surface beyond a certain point. When reached, a spring in line of the control linkage aids in moving the control surface through the remainder of its travel. [**Figure 1-31**]

MASS BALANCE
Flutter is an undesirable oscillation of an aircraft control surface which can have catastrophic effect on controllability of the aircraft. The center of lift on a control surface should be aft of the control surface center of gravity to prevent control surface flutter. Often, the addition of weight to the forward surface of an aileron is sufficient to move the CG of the airfoil forward and prevent flutter. Some aircraft designs place the weight on a lever arm that extends forward of the control surface. This is known as a mass balance. Mass balances help prevent flutter and also reduce the required control stick pressure used to move a control surface. [**Figure 1-32**]

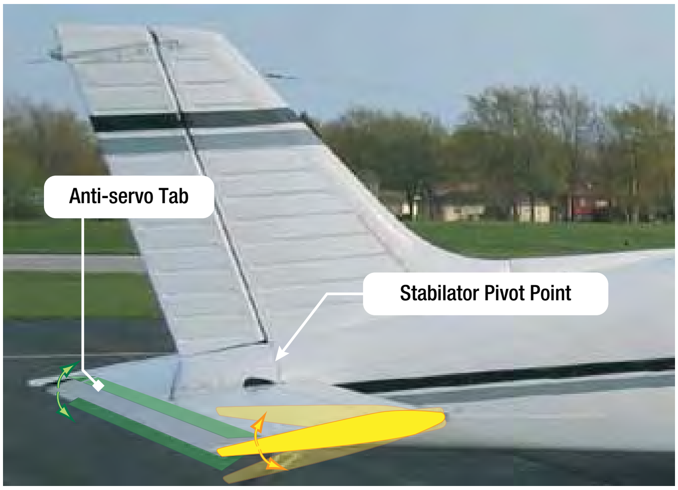

Figure 1-30. An Anti-servo tab moves in the same direction as the control tab. Shown here on a stabilator, it desensitizes the pitch control.

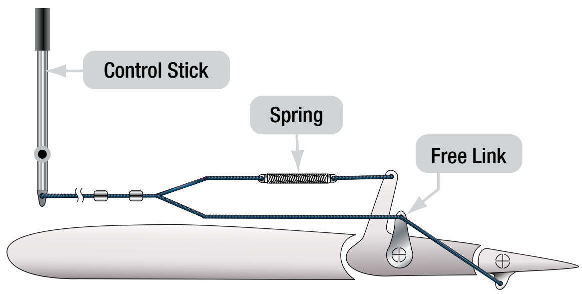

Figure 1-31. Many tab linkages have a spring tab that kicks in as the forces needed to deflect a control increase with speed and the angle of desired deflection.

AERODYNAMIC BALANCE PANELS
Figure 1-33 shows another way of assisting the movement of an aileron on a large aircraft. It is called an aileron balance panel. Not visible when approaching the aircraft, it is positioned in the linkage that hinges the aileron to the wing. Balance panels have been constructed typically of aluminum skin covered frame assemblies or aluminum honeycomb structures. The trailing edge of the wing just forward of the leading edge of the aileron is sealed to allow controlled airflow in and out of the hinge area where the balance panel is located.

WING FENCES
A chordwise barrier on the upper surface of the wing, called a wing fence or stall fence, is used to halt the spanwise flow of air along the wing. During low speed flight, this can maintain proper chordwise airflow reducing the tendency for the wing to stall. Usually made of aluminum, the fence is a fixed structure most common on swept wings, which have a natural spanwise tending boundary air flow. [**Figure 1-34**]

SAW TOOTH LEADING EDGE
A few aircraft have a sawtooth leading edge where, rather than being a smooth continuous surface, the leading edge juts out slightly at a point(s) determined to be beneficial by design engineers. The purpose of the sawtooth wing is to utilize the vortex created by an inboard section of the wing to improve boundary layer flow over an outboard section. This increases lift and resistance to stall. Sawtooth wing leading edges are most common on high performance military aircraft.

BOUNDARY LAYER CONTROL
The boundary layer is a very thin layer of air lying over the surface of the wing and, for that matter, all other surfaces of the aeroplane. Because air has viscosity, this layer of air tends to adhere to the wing. As the wing moves forward through the air, the boundary


Figure 1-32. An aileron mass balance.

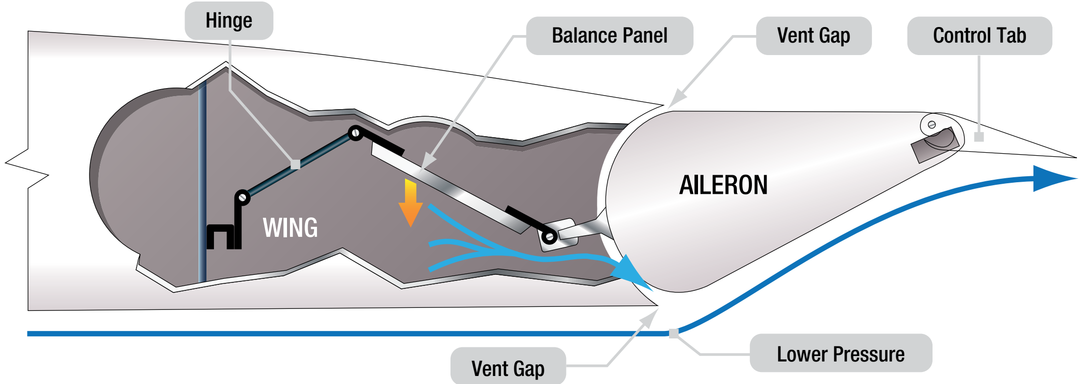

Figure 1-33. An aileron balance panel and linkage uses varying air pressure to assist in control surface positioning.

layer at first flows smoothly over the streamlined shape of the airfoil. This flow is called the laminar layer. As the boundary layer approaches the center of the wing, it begins to lose speed due to skin friction and it becomes thicker and turbulent. Here it is called the turbulent layer.

The point at which the boundary layer changes from laminar to turbulent is called the transition point. Where the boundary layer becomes turbulent, drag due to skin friction is relatively high. As speed increases, the transition point tends to move forward. As the angle of attack increases, the transition point also tends to move forward. With higher angles of attack and further thickening of the boundary layer, the turbulence becomes so great the air breaks away from the surface of the wing. At this point, the lift of the wing is destroyed and a condition known as a stall has occurred.

In **Figure 1-35**, view A shows a normal angle of attack and the airflow staying in contact with the wing. View B shows an extreme angle of attack and the airflow separating and becoming turbulent on the top of the wing. In view B, the wing is in a stall.

VORTEX GENERATORS

Vortex generators are small airfoil sections usually attached to the upper surface of a wing. [**Figure 1-36**] They are designed to promote positive laminar airflow over the wing and control surfaces. Usually made of aluminum and installed in a spanwise line or lines, the vortices created by these devices swirl downward assisting maintenance of the boundary layer of air flowing over the wing. They can also be found on the fuselage and empennage. **Figure 1-37** shows the unique vortex generators on a Symphony SA-160 wing.

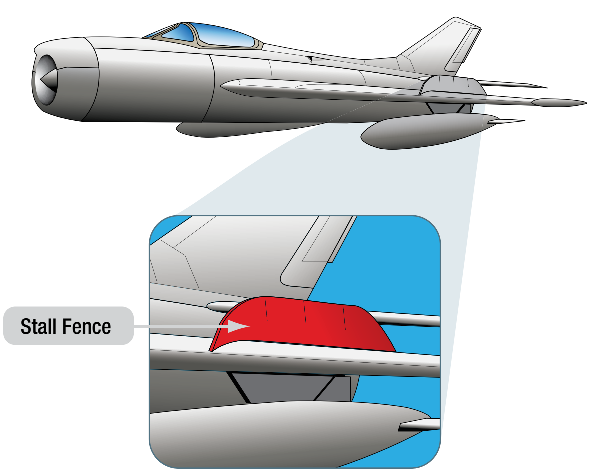

Figure 1-34. A stall fence aids in maintaining chordwise airflow over the wing.

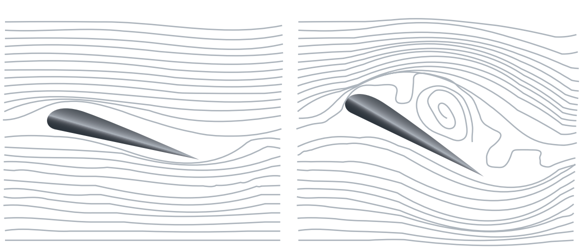

Figure 1-35. Wing boundary layer separation.


Figure 1-36. Vortex generators.


Figure 1-37. The Symphony SA-160 has two unique vortex generators on its wing to ensure aileron effectiveness through the stall.

STALL WEDGES

A stall wedge or stall strip is a fixed wedge shaped strip attached spanwise to the wing leading edge. [**Figure 1-38**] It is located on the inboard section of the wing at such a point that it causes the boundary airflow to become turbulent as the angle of attack increases to a certain point. This purposeful destruction of the boundary airflow as the angle of attack increases causes the root of the wing to stall first. Thus, airflow over the outboard wing section and over the ailerons is preserved during the stall making it easier to recover. A wedge can also serve as a stall warning device by invoking turbulence with vibrations warning the pilot.

WING TIP VORTICES

Wingtip vortices are caused by the air beneath the wing, which is at the higher pressure, flowing over the wingtip and up toward the top of the wing. The end result is a spiral or vortex that trails behind the wingtip anytime lift is being produced. This vortex is also referred to as wake turbulence, and is a significant factor in determining how closely one aeroplane can follow behind another on approach to land. The wake turbulence of a large aeroplane can cause a smaller aeroplane, if it is following too closely, to be thrown out of control. Vortices from the wingtip as well as the inboard edge of the ailerons and from the horizontal stabilizer are visible on the MD-11 shown in **Figure 1-39**.

Upwash and downwash refer to the effect an airfoil has on the free airstream. Upwash is the deflection of the oncoming airstream, causing it to flow up and over the wing. Downwash is the downward deflection of the airstream after it has passed over the wing and is leaving the trailing edge. This downward deflection is what creates the action and reaction described under lift and Newton's third law.

WINGLETS

A winglet is an obvious vertical upturn of the wing's tip resembling a vertical stabilizer. [**Figure 1-40**] It is an aerodynamic device designed to reduce the drag created by wing tip vortices in flight. Usually made from aluminum or composite materials, winglets can be designed to optimize performance at a desired speed. They use the flow of air from under the wing to create thrust thereby reducing induced drag. Significant fuel savings are also achieved.

Altitude in Feet	Temperature (°C)	Speed of Sound (m/s)
0	15.00	340
1 000	13.01	399
2 000	11.04	338
3 000	9.06	337
4 000	7.08	335
5 000	5.09	334
6 000	3.11	333
7 000	1.13	332
8 000	−0.85	331
9 000	−2.83	329
10 000	−4.81	328
15 000	−14.72	322
20 000	−24.62	316
25 000	−34.53	309
30 000	−44.43	303
35 000	−54.34	296
*36 089	−56.50	295
40 000	−56.50	295
45 000	−56.50	295
50 000	−56.50	295
55 000	−56.50	295
60 000	−56.50	295
65 000	−56.50	295
70 000	−56.50	295
75 000	−56.50	295
80 000	−56.50	295
85 000	−53.78	297
90 000	−49.21	300
95 000	−44.63	303
100 000	−40.06	306

*Altitude at which temperature stops decreasing

Figure 1-39. Altitude and temperature versus speed of sound.

Figure 1-38. A stall wedge causes the wing root to stall before the outboard wing. This preserves airflow over the ailerons for controlled recovery from the stall.

Figure 1-40. A winglet reduces aerodynamic drag caused by air spilling off of the wing tip.