

AVIATION MAINTENANCE TECHNICIAN CERTIFICATION SERIES

TURBINE AEROPLANE STRUCTURES AND SYSTEMS

11



EASA 2023-889 COMPLIANT

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VERSION	EFFECTIVE DATE	DESCRIPTION OF REVISION(S)
001	2015.01	Module creation and release.
002	2024.06	Regulatory update for EASA 2023-989 Compliance.

Module was reorganized based upon the EASA 2023-989 subject criteria. Enhancements included in this version 002 are:

- 11.1.2 *High Speed Flight* - topic moved to Module 8 Basic Aerodynamics.
- 11.3.1 *Airborne Towing Devices* - topic added.
- 11.5.2 *Avionics Test Equipment* - topic added.
- 11.10 *Inert Gas Systems* - topic added.
- 11.11 *Tail Protection* - topic added.
- 11.16 *Pneumatic Pumps* - topic added.
- Question and Answer updates for all Submodules.

TABLE OF CONTENTS

TURBINE AEROPLANE STRUCTURES AND SYSTEMS

Revision Log	iii
Measurement Standards	iv
Basic Knowledge Requirements	v
Part 66 Basic Knowledge Requirements	vi
Table of Contents	xi

11.1 THEORY OF FLIGHT 1.1

Section A	1.1
Primary Flight Control Surfaces	1.1
Roll Control Devices	1.2
Ailerons	1.2
Spoilers	1.3
Pitch Control Devices	1.3
Elevators	1.3
Stabilators	1.4
Variable Incidence Stabilizers	1.4
Canards	1.4
Yaw Control Devices	1.5
Rudders	1.5
Rudder Limiters	1.5
Elevons and Ruddervators	1.5
Elevons	1.5
Ruddervators	1.5
High Lift Devices	1.5
Slots	1.5
Slats	1.6
Flaps	1.6
Flaperons	1.7
Drag Inducing Devices	1.8
Secondary and Auxiliary Control Surfaces	1.8
Trim Tabs	1.8
Servo Tabs	1.9
Control Surface Bias	1.9
Section B	1.9
Operation and Effects	1.9
Balance Tabs	1.9
Anti-Servo/Anti-Balance Tabs	1.9
Spring Tabs	1.9
Mass Balance	1.10
Aerodynamic Balance Panels	1.10
Wing Fences	1.10
Saw Tooth Leading Edge	1.10
Boundary Layer Control	1.11
Vortex Generators	1.11
Stall Wedges	1.11
Submodule 1 Practice Questions	1.13
Submodule 1 Practice Answers	1.14

11.2 AIRFRAME STRUCTURES (ATA 51)..... 2.1

Section A	2.1
Zonal And Station Identification Systems	2.1
Zonal Identification System	2.2
Access And Inspection Panels	2.2
Electrical Bonding	2.4

Bonding Procedures and Precautions	2.4
Lightning Strike Protection	2.4
Section B	2.5
Structural Classification	2.5
Primary Structure	2.5
Secondary Structure	2.5
Tertiary Structure	2.5
Damage Tolerant Concepts	2.5
Fail Safe	2.5
Safe Life	2.5
Damage Tolerance	2.5
Structural Stresses	2.6
Hoop Stress	2.6
Metal Fatigue	2.6
Drains and Ventilation	2.7
Drainage	2.7
Ventilation	2.8
System Installation Provisions	2.8
Section C	2.8
Airframe Structural Methods	2.8
Fuselage Types	2.8
Truss Type	2.8
Stressed Skin Monocoque	2.8
Semimonocoque Type	2.9
Fuselage Components	2.9
Frames	2.9
Formers	2.9
Stringers and Longerons	2.9
Bulkheads	2.9
Doublers	2.10
Struts & Ties	2.10
Reinforcement	2.10
Skinning	2.10
Wing and Empennage Attachment	2.11
Engine Attachment	2.12
Structural Assembly Techniques	2.12
Corrosion Protection	2.13
Methods of Surface Protection	2.14
Chromating	2.14
Anodizing	2.15
Cladding	2.15
Painting	2.15
Surface Cleaning	2.15
Exterior Aircraft Cleaning	2.15
Airframe Symmetry	2.15
Checking Dihedral	2.17
Checking Incidence	2.17
Checking Fin Verticality	2.17
Checking Engine Alignment	2.18
Symmetry Check	2.18
Submodule 2 Practice Questions	2.19
Submodule 2 Practice Answers	2.20

TABLE OF CONTENTS

11.3 AIRFRAME STRUCTURES — AEROPLANES.....	3.1	11.4 AIR CONDITIONING AND CABIN PRESSURIZATION	4.1
11.3.1 Section A.	3.1	(ATA 21)	4.1
Fuselage, Doors, Windows (ATA 52/53/56).	3.1	Section A.	4.1
Fuselage Construction.	3.1	Pressurization Terms.	4.1
Pressurization Sealing.	3.1	Pressurization Systems.	4.1
Attachments.	3.2	Cabin Pressure Controllers, Control and Safety Valves.	4.1
Wings.	3.2	Pressurization Modes.	4.1
Stabilizers.	3.2	Cabin Pressure Controllers.	4.2
Pylons.	3.2	Control Valve (Outflow Valve).	4.3
Undercarriage.	3.2	Control and Indication.	4.3
Seat Installation.	3.2	Cabin Air Pressure Safety Valve Operation.	4.3
Windows and Windscreens.	3.3	Pressurization Indication.	4.3
Construction.	3.3	Pressurization Operation.	4.4
Mechanisms.	3.3	Cabin Pressurization Troubleshooting.	4.5
Attachment.	3.3	Section B.	4.5
Windscreens.	3.4	Sources of Air Supply.	4.5
11.3.1 Section B.	3.5	Bleed Air.	4.5
Airborne Towing Devices.	3.5	Auxiliary Power Unit (APU).	4.5
Tow Hook Inspection.	3.5	Ground Cart.	4.5
11.3.1 Section C.	3.5	Section C.	4.8
Doors and Emergency Exits.	3.5	Air Cycle Air Conditioning.	4.8
Construction.	3.5	System Operation.	4.8
Mechanisms.	3.5	Pneumatic System Supply.	4.8
Cargo Loading Systems.	3.6	Component Operation.	4.8
11.3.2 Wings (ATA 57).	3.6	Pack Valve.	4.8
Wing Construction.	3.6	Bleed Air Bypass.	4.8
Wing Spars.	3.7	Primary Heat Exchanger.	4.8
Wing Ribs.	3.9	Refrigeration Turbine Unit or Air Cycle Machine	
Wing Roots and Tips.	3.9	and Secondary Heat Exchanger.	4.9
Wing Skin.	3.9	Water Separator.	4.10
Fuel Storage.	3.9	Refrigeration Bypass Valve.	4.10
Attachments.	3.12	Vapor Cycle Air Conditioning.	4.10
Landing Gear.	3.12	Theory of Refrigeration.	4.11
Pylons.	3.12	Basic Vapor Cycle.	4.11
Control Surfaces.	3.12	Vapor Cycle Air Conditioning System Components.	4.11
High Lift and Drag Devices.	3.12	Refrigerant.	4.11
11.3.3 Stabilizers (ATA 55).	3.13	Receiver Dryer.	4.12
Stabilizer Construction.	3.13	Expansion Valve.	4.13
Stabilizer Attachment.	3.14	Evaporator.	4.13
11.3.4 Flight Control Surfaces (ATA 57).	3.14	Compressor.	4.13
Construction and Attachment.	3.14	Condenser.	4.14
Balancing Flight Controls.	3.15	Service Valves.	4.14
Static Balancing.	3.15	Flow, Temperature and Humidity Control.	4.15
Aerodynamic (Dynamic) Balancing.	3.15	Flow Control.	4.15
11.3.5 Nacelles/Pylons (ATA 54).	3.15	Temperature Control.	4.15
Nacelles.	3.15	Humidity Control.	4.15
Nose Cowl.	3.15	Section D.	4.16
Cowling Doors.	3.15	Protection and Warning Devices.	4.16
Pylons.	3.15	Submodule 4 Practice Questions.	4.17
Firewalls.	3.16	Submodule 4 Practice Answers.	4.18
Submodule 3 Practice Questions.	3.17	11.5 INSTRUMENTS/AVIONICS SYSTEMS.....	5.2
Submodule 3 Practice Answers.	3.18	Instrument Systems.	5.2
		Classifying Instruments.	5.2
		Flight Instruments.	5.3
		Engine Instruments.	5.3

TABLE OF CONTENTS

Navigation Instruments	5.3	AC Synchro Systems	5.31
Pitot-Static Systems	5.4	Remote Indicating Fuel and Oil Pressure Gauges	5.31
Pitot Tubes and Static Vents	5.4	Glass Cockpit	5.31
Air Data Computers	5.6	Autoflight	5.33
Pitot-Static Pressure Sensing Flight Instruments	5.7	Basis For Autopilot Operation	5.33
Altimeters	5.7	Autopilot Components	5.33
Airspeed Indicators	5.9	Sensing Elements	5.34
Machmeters	5.9	Computer and Amplifier	5.34
Vertical Speed Indicators	5.10	Output Elements	5.34
Gyroscopic Instruments	5.11	Command Elements	5.35
Sources of Power for Gyroscopic Instruments	5.11	Autopilot Functions	5.36
Pressure Driven Gyroscopic Instruments	5.11	Yaw Dampening	5.36
Electrically Driven Gyroscopic Instruments	5.11	Automatic Flight Control System	5.36
Principles Of Gyroscopic Instruments	5.11	Communications	5.37
Solid State Gyro Systems	5.12	Very High Frequency (VHF) Radios	5.38
Ring Laser Gyros	5.13	High Frequency Radios	5.38
Microelectromechanical Attitude And Directional Systems	5.13	Selective Calling	5.38
Attitude Heading and Reference Systems (AHRS)	5.14	Satellite Communication Systems (SATCOM)	5.38
Common Gyroscopic Instruments	5.14	Controller Pilot Data Link Communications (CPDLC)	5.38
Vacuum Driven Attitude Gyros	5.14	Audio Systems	5.38
Electric Attitude Indicators	5.15	Service Interphone System	5.38
Gyroscopic Direction Indicator/Directional Gyro (DG)	5.15	Emergency Locator Transmitter (ELT)	5.39
Turn Coordinators	5.16	Cockpit Voice Recorders	5.39
Turn And Slip Indicators	5.16	Navigation Systems	5.41
Compass Systems	5.17	VOR Navigation System	5.41
Direct Indicating Magnetic Compass	5.17	Automatic Direction Finder (ADF)	5.43
Vertical Magnetic Compass	5.17	Instrument Landing Systems (ILS)	5.44
Remote Indicating Compass	5.18	Localizer	5.44
Remote Indicating Slaved Gyro Compass (Flux Gate Compass)	5.18	Glideslope	5.45
Solid State Magnetometers	5.19	Compass Locators	5.46
Stall Warning and Angle of Attack Indicators	5.19	Marker Beacons	5.46
Pressure Measuring Instruments	5.20	Microwave Landing Systems	5.47
Types of Pressure	5.22	Flight Director Systems	5.47
Pressure Instruments	5.22	Distance Measuring Equipment (DME)	5.48
Engine Oil Pressure	5.22	Area Navigation (RNAV)	5.49
Engine Pressure Ratio (EPR)	5.22	Flight Management Systems (FMS)	5.49
Fuel Pressure	5.23	Satellite Navigation Systems	5.51
Hydraulic Pressure	5.23	Global Positioning System	5.51
Vacuum Pressure	5.23	Wide Area Augmentation System	5.51
Pressure Switches	5.24	Air Traffic Control Transponder	5.52
Mechanical Movement Indicators	5.25	Transponder Tests And Inspections	5.54
Tachometers	5.25	Altitude Encoders	5.54
Electric Tachometers	5.25	Collision Avoidance Systems	5.54
Synchroscope	5.26	Traffic Collision Avoidance Systems (TCAS)	5.54
Temperature Measuring Instruments	5.27	ADS-B	5.56
Non-Electric Temperature Indicators	5.27	Weather Radar	5.57
Electrical Temperature Measuring Indication	5.28	Radio Altimeter	5.59
Electrical Resistance Thermometer	5.28	Inertial Navigation Systems	5.59
Ratiometer Electrical Resistance Thermometers	5.28	ARINC Communications and Reporting	5.60
Thermocouple Temperature Indicators	5.29	Communication and Navigation Avionics Installations	5.61
Turbine Gas Temperature Indicating Systems	5.29	Avionics General Test Equipment	5.61
Total Air Temperature Measurement	5.30	Built in Test Equipment	5.61
Remote Sensing and Indication	5.30	Avionics Test Equipment	5.62
Synchro Type Remote Indicating Instruments	5.30	Multimeters	5.62
DC Selsyn Systems	5.30	Oscilloscope	5.62
		Pitot-Static Test Equipment	5.63

TABLE OF CONTENTS

Specialized Test Equipment	5.63	Cabin Furnishing Installation	7.4
Data Bus Analyzers	5.63	Cabin Entertainment Equipment	7.4
Test Equipment Calibration	5.63	Galley Installation	7.4
Submodule 5 Practice Questions	5.73	Cargo Handling And Retention Equipment	7.5
Submodule 5 Practice Answers	5.74	Airstairs	7.6
Submodule 5 Practice Questions	5.75	Submodule 7 Practice Questions	7.7
Submodule 5 Practice Answers	5.76	Submodule 7 Practice Answers	7.8
11.6 ELECTRICAL POWER (ATA 24).....	6.1	11.8 FIRE PROTECTION (ATA 26).....	8.1
Battery Charging	6.1	Section A	8.1
Constant Volt Charging	6.2	Fire Protection	8.1
Constant Current Charging	6.2	Requirements For Fire To Occur	8.1
Battery Inspection	6.2	Classes of Fires	8.1
Installation Practices	6.2	Fire Zones	8.1
Battery Troubleshooting	6.2	Fire Prevention	8.2
DC Power Generation	6.2	Fire Detection and Warning Systems	8.2
Generator Control Systems	6.2	Requirements For Overheat and Fire Detection Systems	8.2
Voltage Regulation	6.4	Thermal Switch Systems	8.2
Over Voltage Protection	6.4	Thermocouple Systems	8.3
Parallel Generator Operations	6.4	Continuous Loop Systems	8.3
Reverse Current Sensing	6.4	Fenwal System	8.3
Generator Controls for High Output Generators	6.4	Kidde System	8.4
Other Voltage Regulation	6.4	Sensing Element	8.4
AC Power Generation	6.5	Combination Fire and Overheat Warning	8.5
AC Alternators	6.5	Temperature Trend Indication	8.5
Alternator Drive	6.6	System Test	8.5
AC Alternator Control Systems	6.7	Fault Indication	8.5
Emergency Power Generation	6.8	Dual Loop Systems	8.5
Standby Power	6.8	Automatic Self Interrogation	8.5
Power Distribution on Small Multi-Engine Aircraft	6.8	Support Tube Mounted Sensing Elements	8.5
Power Distribution on Large Aircraft	6.9	Fire Detection Control Unit (Fire Detection Card)	8.6
Split Bus Systems	6.9	Pressure Sensor Responder Systems	8.6
Parallel Bus Systems	6.10	Pneumatic Continuous Loop Systems	8.6
Split Parallel Systems	6.10	Averaging Function	8.6
Inverters, Transformers and Rectifiers	6.11	Discrete Function	8.6
Inverters	6.11	Smoke, Flame, And Carbon Monoxide Detection Systems	8.7
Rotary Inverters	6.11	Smoke Detectors	8.7
Static Inverters	6.11	Light Refraction Type	8.7
Transformers	6.12	Ionization Type	8.7
Rectifiers	6.13	Flame Detectors	8.7
Circuit Protection	6.14	Carbon Monoxide Detectors	8.7
Current Limiting Devices	6.14	Fire Extinguishing Systems	8.8
Fuses	6.14	Fire Extinguisher Agents	8.8
Circuit Breakers	6.14	Fixed Container Fire Extinguishing Systems	8.9
External/Ground Power	6.15	Containers	8.9
Submodule 6 Practice Questions	6.17	Discharge Valves	8.9
Submodule 6 Practice Answers	6.18	Pressure Indication	8.10
		Two Way Check Valve	8.11
		Discharge Indicators	8.11
		Thermal Discharge Indicator (Red Disk)	8.11
		Normal Discharge Indicator (Yellow Disk)	8.11
		Fire Switch	8.11
		Fire Protection in Cargo Compartments	8.11
		Cargo Compartment Classification	8.11
		Cargo Compartment Fire Protection and Warning	8.12
		Smoke Detector Systems	8.12
11.7 EQUIPMENT AND FURNISHINGS (ATA 25).....	7.1		
Section A	7.1		
Emergency Equipment Requirements	7.1		
Section B	7.2		
Seats, Harnesses, And Belts	7.2		
Seats	7.2		
Seat Belts and Harnesses	7.2		
Equipment Layout	7.3		

TABLE OF CONTENTS

Cargo Compartment Extinguishing Systems	8.13	Static Balance	9.10
Fire Protection in Lavatories	8.13	Dynamic Balance	9.11
Lavatory Smoke Detector and Warning Systems	8.13	Rebalancing	9.11
Lavatory Fire Extinguisher Systems	8.14	Rebalancing Methods	9.11
System Tests and Maintenance	8.14	Aircraft Rigging	9.11
Fire Detection Maintenance	8.14	Submodule 9 Practice Questions	9.13
Fire Detection System Troubleshooting	8.16	Submodule 9 Practice Answers	9.14
Fire Extinguisher System Maintenance	8.16		
Container Pressure Check	8.16	11.10 FUEL SYSTEMS (ATA 28, ATA 47)	10.1
Discharge Cartridges	8.16	Section A	10.1
Agent Containers	8.17	Fuel Systems	10.1
Section B	8.17	Fuel System Layout	10.1
Cockpit and Cabin Interiors	8.17	Fuel Tanks	10.1
Portable Extinguisher Types	8.17	Integral Fuel Tanks	10.1
Operation of Portable Fire Extinguishers	8.18	Bladder Fuel Tanks	10.2
Inspection of Portable Fire Extinguishers	8.18	Fuel Supply Systems	10.3
Maintenance of Portable Fire Extinguishers	8.18	Fuel System Components	10.4
Submodule 8 Practice Questions	8.21	Fuel Lines and Fittings	10.4
Submodule 8 Practice Answers	8.22	Fuel Valves	10.5
		Manually Operated Gate Valves	10.5
11.9 FLIGHT CONTROLS (ATA 27)	9.1	Motor Operated Valves	10.6
Primary and Secondary Flight Controls	9.1	Solenoid Operated Valves	10.6
Primary Controls	9.1	Fuel Pumps	10.6
Elevators	9.1	Centrifugal Boost Pumps	10.7
Ailerons	9.1	Ejector Pumps	10.7
Rudder	9.2	Fuel Filters	10.7
Secondary Flight Controls	9.3	Fuel System Repairs	10.8
Trim Control, Trim Tabs	9.3	Troubleshoot the Fuel System	10.8
High Lift Devices	9.3	Location of Leaks and Defects	10.9
Control System Operation	9.4	Fuel Leak Classification	10.9
Mechanical Control	9.4	Replacement of Gaskets, Sals, and Packings	10.10
Control Cables	9.4	Section B	10.10
Bellcranks and Levers	9.5	Fuel Handling	10.10
Jackscrews	9.5	Cross-Feed and Transfer Systems	10.10
Torque Tubes	9.6	Refueling and Defueling	10.11
Gust Locks and Gust Lock Systems	9.6	Fueling	10.11
Artificial Feel, Yaw Damper, Mach Trim, Rudder Limiter	9.6	Over the Wing Fueling	10.11
Artificial Feel	9.6	Pressure Refueling	10.11
Yaw Damper	9.6	Defueling	10.12
Mach Trim	9.7	Fire Hazards when Fueling or Defueling	10.12
Rudder Limiter	9.7	Fuel Servicing and Contamination	10.13
Stall Warning Systems	9.7	Fuel and Fuel system Contaminates	10.13
Takeoff Configuration Warnings	9.7	Water	10.13
Landing Configuration Warnings	9.7	Solid Particle Contaminates	10.13
Section B	9.8	Surfactants	10.14
Active Load Control	9.8	Microorganisms	10.14
Hydraulic and Pneumatic Actuation Systems	9.8	Foreign Fuel Contamination	10.14
Hydromechanical Control	9.8	Detection of Contaminates	10.15
Pneumatic Control	9.9	Fuel Contamination Control	10.16
Stall Protection Systems	9.9	Section C	10.17
Section C	9.9	Indications and Warning	10.17
Electric and Electronic Control	9.9	Fuel Quantity Indicating Systems	10.17
Fly-By-Wire Control	9.10	Ratiometer Indicating Systems	10.17
Fly-By-Optics Control	9.10	Capacitance Indicating Systems	10.17
Fly-By-Wireless Control	9.10	Mechanical Indicating Systems	10.18
Section D	9.10	Fuel Flowmeters	10.18

TABLE OF CONTENTS

Fuel Temperature Gauges	10.18	Filters	11.10
Fuel Heaters	10.18	Micron Type Filters	11.10
Fuel Pressure Gauges	10.18	Maintenance of Filters	11.10
Pressure Warning Signal	10.19	Filter Bypass Valves	11.11
Valve In Transit Indicator Lights	10.19	Filter Differential Pressure Indicators	11.11
Section D	10.19	Heat Exchangers	11.11
Special Systems	10.19	Power Distribution	11.11
Dumping, venting, and draining	10.19	Shutoff Valves	11.12
Fuel System Drains	10.19	Selector Valves	11.12
Fuel Vent Systems	10.21	Check Valves	11.12
Fuel Jettisoning Systems	10.21	Orifice Type Check Valves	11.13
Inert Gas Systems	10.21	Sequence Valves	11.13
Section E	10.22	Priority Valves	11.14
Longitudinal Balance Systems	10.22	Shuttle Valves	11.14
Submodule 10 Practice Questions	10.23	Quick Disconnect Valves	11.14
Submodule 10 Practice Answers	10.24	Hydraulic Fuses	11.14
		Hydraulic Actuators	11.14
		Linear Actuators	11.15
		Rotary Actuators	11.15
11.11 HYDRAULIC POWER (ATA 29)	11.1	Section B	11.16
Section A	11.1	System Operation	11.16
System Layout	11.1	Pressure Generation: Electric and Mechanical	11.16
Open Center Hydraulic Systems	11.2	Hand Pumps	11.16
Closed Center Hydraulic Systems	11.2	Powered Pump Classification	11.16
Evolution of Hydraulic Systems	11.3	Constant Displacement Pumps	11.16
Hydraulic Powerpack Systems	11.3	Gear Type Power Pump	11.17
Modern High Performance Systems	11.3	Gerotor Pump	11.17
Hydraulic Fluid Properties	11.3	Piston Pumps	11.17
Viscosity	11.3	Vane Pump	11.17
Chemical Stability	11.3	Variable Displacement Pumps	11.18
Flash Point	11.4	Basic Pumping Operation	11.18
Fire Point	11.4	Pressure Control	11.19
Hydraulic Fluid Types	11.4	Relief Valves	11.19
Mineral Based Fluids	11.4	Pressure Regulators	11.20
Polyalphaolefin Based Fluids	11.4	Pressure Reducers	11.20
Phosphate Ester Based Fluid (Skydrol®)	11.4	Hydraulic Seals	11.20
Intermixing of Fluids	11.4	Packings	11.20
Compatibility with Aircraft Materials	11.4	V-Rings	11.20
Hydraulic Fluid Contamination	11.4	U-Rings	11.20
Contamination Check	11.4	O-Rings	11.20
Sampling Schedule	11.5	O-Ring Color Coding	11.21
Contamination Control	11.5	Backup Rings	11.22
Filters	11.5	O-Ring Installation	11.22
Hydraulic System Flushing	11.5	Gaskets	11.22
Health and Handling	11.5	Wipers	11.22
Reservoirs and Accumulators	11.5	Hydraulic Indication and Warning	11.23
Reservoirs	11.5	Servicing	11.24
Non-Pressurized Reservoirs	11.6	Hydraulic Fluid Contamination	11.25
Pressurized Reservoirs	11.6	Contamination Prevention	11.26
Air Pressurized Reservoirs	11.6	Fluid Monitoring	11.26
Fluid Pressurized Reservoirs	11.7	Hydraulic System Maintenance & Troubleshooting	
Reservoir Servicing	11.8	Checklist	11.26
Accumulators	11.8	Section C	11.27
Types of Accumulators	11.9	System Operation	11.27
Spherical Accumulators	11.9	Pressure Generation: Pneumatic	11.27
Cylindrical Accumulators	11.9	Emergency Pressure Generation	11.27
Operation of Accumulators	11.9		
Maintenance of Accumulators	11.10		

TABLE OF CONTENTS

Ram Air Turbine	11.27	WAI Indication System	12.16
Hydraulic Motors	11.27	WAI System BITE Test	12.16
Power Transfer Unit (PTU)	11.28	Engine Anti-Ice (EAI)	12.16
Hydraulic Motor Driven Generators (HMDGS)	11.28	Chemical Anti-Ice	12.17
Interface with Other Systems	11.28	Wipers	12.17
Submodule 11 Practice Questions	11.29	Windshield Wiper Systems	12.18
Submodule 11 Practice Answers	11.30	Pneumatic Rain Removal Systems	12.18
11.12 ICE AND RAIN PROTECTION (ATA 30)	12.1	Section E	12.18
Section A	12.1	Rain Repellent Systems	12.18
Principles	12.1	Chemical Rain Repellent	12.18
Ice Formation	12.1	Windshield Surface Seal Coating	12.20
Icing Effects	12.1	Submodule 12 Practice Questions	12.21
Classification	12.2	Submodule 12 Practice Answers	12.22
Detection	12.2	11.13 LANDING GEAR (ATA 32)	13.1
Section B	12.3	Section A	13.1
De-icing	12.3	Description	13.1
Anti-ice Versus De-ice	12.3	Construction, Shock Absorbing	13.1
De-icing Systems	12.3	Landing Gear Configuration	13.1
Electrical De-Icing Systems	12.3	Tail Wheel Type Landing Gear	13.1
Electric Propeller De-Ice	12.3	Tandem Landing Gear	13.1
Electric Airfoil De-Ice Boots	12.3	Tricycle Landing Gear	13.2
Hot Air De-Ice/De-Fog	12.3	Fixed and Retractable Landing Gear	13.4
Pneumatic De-Ice Boots	12.4	Landing Gear Alignment and Support	13.5
Construction and Installation of De-Ice Boots	12.4	Alignment	13.5
Sources of Operating Air	12.4	Support	13.6
De-Ice system for Turboprop Aircraft	12.5	Shock Absorbing	13.7
Inspection, Maintenance and Troubleshooting of Rubber De-Icer Boot Systems	12.6	Shock Struts	13.7
Operational Checks	12.6	Shock Strut Operation	13.8
Adjustments	12.7	Servicing Shock Struts	13.10
Troubleshooting	12.8	Bleeding Shock Struts	13.10
Inspection	12.8	Tires and Tubes	13.11
De-Ice Boot Maintenance	12.8	Tire Classification	13.11
Chemical De-Ice Systems	12.9	Ply Rating	13.12
Windshield Chemical De-Ice	12.9	Tube Type or Tubeless	13.12
Propeller Chemical De-Ice	12.9	Bias Ply or Radial	13.12
Ground Chemical De-Icing of Aircraft	12.9	Tire Construction	13.12
Frost Removal	12.9	Bead	13.12
De-Icing Fluid	12.9	Carcass Plies	13.12
Holdover Time (HOT)	12.9	Tread	13.12
Critical Surfaces	12.10	Sidewall	13.13
Ice and Snow Removal	12.10	Chine	13.13
Probe and Drain Heating	12.11	Tire Inspection on the Aircraft	13.14
Probe De-Ice/Anti-Ice	12.11	Inflation	13.14
Water System and Drain De-Ice/Anti-Ice	12.12	Tread Condition	13.14
Section C	12.12	Tread Depth and Wear Pattern	13.14
Anti-icing	12.12	Tread Damage	13.15
Thermal Electrical Anti-Icing	12.12	Sidewall Condition	13.17
Windshield Anti-Ice	12.12	Tire Inspection Off the Aircraft	13.19
Propeller Anti-Ice	12.13	Tire Storage	13.19
Thermal Pneumatic Anti-Ice	12.13	Aircraft Tubes	13.19
Wing Anti-Ice Systems (WAI)	12.13	Tube Construction and Selection	13.19
Slat Leading Edges	12.14	Tube Storage and Inspection	13.20
WAI Operation	12.14	Tube Tire Inspection	13.20
WAI Control	12.16	Tire Mounting	13.20
		Tubeless Tires	13.20

TABLE OF CONTENTS

Tube Type Tires	13.21	Touchdown and lock Wheel Protection	13.48
Tire Balancing	13.22	Antiskid System Tests	13.48
Section B	13.23	Ground Test	13.48
Systems	13.23	Inflight Test	13.49
Extension and Retraction Systems: Normal and Emergency	13.23	Antiskid System Maintenance	13.49
Normal Operation	13.23	Wheel Speed Sensor	13.49
Nose Wheel Centering	13.24	Control Valve	13.49
Emergency Operation	13.24	Control Unit	13.49
Landing Gear Retraction Test	13.24	Autobraking	13.49
Indications and Warnings	13.25	Brake Inspection and Service	13.49
Landing Gear Safety Devices	13.25	On Aircraft Servicing	13.49
Ground Locks	13.25	Lining Wear	13.49
Safety Switches	13.26	Air in the Brake System	13.50
Proximity Sensors	13.26	Bleeding Master Cylinder Brake Systems	13.50
Wheels, Brakes, Antiskid, and Autobraking	13.26	Bleeding Power Brake Systems	13.51
Aircraft Wheels	13.26	Inspection For Leaks	13.52
Wheel Construction	13.26	Proper Bolt Torque	13.52
Inboard Wheel Half	13.27	Off Aircraft Brake Maintenance	13.52
Outboard Wheel Half	13.28	Bolt and Threaded Connections	13.52
Wheel Inspection	13.28	Discs	13.52
On Aircraft Inspection	13.28	Automatic Adjuster Pins	13.52
Proper Installation	13.29	Torque Tube	13.52
Axle Nut Torque	13.29	Brake Housing and Piston Condition	13.53
Off Aircraft Wheel Inspection	13.29	Seal Condition	13.53
Disassembly of the Wheel	13.30	Replacement of Brake Linings	13.53
Cleaning the Wheel Assembly	13.30	Brake Malfunctions and Damage	13.53
Inspection of the Wheel Halves	13.30	Overheating	13.53
Wheel Tie Bolt Inspection	13.30	Dragging	13.53
Key and Key Screw Inspection	13.31	Chattering or Squealing	13.53
Fusible Plug Inspection	13.31	Steering	13.54
Wheel Bearings	13.31	Steering Damper	13.54
Cleaning the Wheel Bearings	13.31	Shimmy Dampers	13.54
Inspection of Wheel Bearings	13.31	Piston Type	13.54
Bearing Handling and Lubrication	13.33	Vane Type	13.54
Aircraft Brakes	13.33	Non-Hydraulic Shimmy Damper	13.55
Types and Construction of Aircraft Brakes	13.33	Landing Gear System Maintenance	13.55
Single Disc Brakes	13.33	Landing Gear Rigging and Adjustment	13.56
Floating Disc Brakes	13.34	Adjusting Landing Gear Latches	13.56
Fixed Disc Brakes	13.34	Gear Door Clearances	13.57
Dual Disc Brakes	13.35	Drag and Side Brace Adjustment	13.57
Multiple Disc Brakes	13.36	Section C	13.57
Segmented Rotor Disc Brakes	13.37	Air-Ground Sensing	13.57
Carbon Brakes	13.37	Section D	13.58
Brake Actuating Systems	13.38	Tail Protection	13.58
Independent Master Cylinders	13.38	Skids	13.58
Boosted Brakes	13.41	Tail Stands	13.59
Power Brakes	13.41	Submodule 13 Practice Questions	13.61
Brake Control Valve/Brake Metering Valve	13.43	Submodule 13 Practice Answers	13.62
Emergency Brake Systems	13.44	Submodule 13 Practice Questions	13.63
Parking Brake	13.45	Submodule 13 Practice Answers	13.64
Brake Deboosters	13.45	11.14 LIGHTS..... 14.1	
AntiSkid Systems	13.46	External: Navigation, Anti-Collision, Landing, Taxiing, Ice	14.1
System Operation	13.46	Navigation/Position Lights	14.1
Wheel Speed Sensors	13.47	Anti-Collision Lights	14.2
Control Units	13.47	Rotating Beacons	14.2
Antiskid Control Valves	13.48		

TABLE OF CONTENTS

Strobe Lighting	14.2	Restrictors	16.2
Landing Lights	14.3	Variable Restrictor	16.2
Taxi Lights	14.3	Filters	16.3
Wing Ice Inspection Lights	14.3	Desiccant/Moisture Separator.	16.3
Internal: Cabin, Cockpit, Cargo	14.3	Chemical Drier	16.3
Cabin Lighting	14.4	Sources	16.3
Cockpit Lighting	14.4	Storage	16.3
Integral Instrument Lighting	14.5	Charging	16.3
Cargo Compartment Lights	14.5	Distribution	16.3
Emergency Lighting	14.5	Supply Regulation	16.4
Electroluminescence	14.6	Emergency Back-up Systems and Pneudraulics	16.4
Self Illuminating Signs	14.6	Nitrogen Bottles.	16.4
Emergency Exit Lighting Activation	14.6	High-pressure Pneumatic System Maintenance	16.4
Submodule 14 Practice Questions	14.7	Medium Pressure Pneumatic Systems.	16.4
Submodule 14 Practice Answers	14.8	System Layout	16.4
11.15 OXYGEN (ATA 35)..... 15.1		Sources	16.4
Human Respiration and Circulation	15.1	Storage	16.4
Sources, Storage, Charging and Distribution	15.2	Pressure Control	16.5
Sources of Oxygen	15.2	Distribution	16.5
Gaseous Oxygen Tanks	15.2	Vacuum Systems.	16.5
Chemical and Solid Oxygen	15.2	Indications and Warnings	16.5
Onboard Oxygen Generating Systems	15.3	Interface with Other Systems	16.6
Liquid Oxygen.	15.3	Section B	16.6
Oxygen Charging	15.3	Pumps	16.6
Oxygen Distribution	15.4	Pressure and Vacuum Pumps.	16.6
Supply Regulation	15.5	Classification of Pumps	16.6
Continuous Flow Systems	15.5	Types of Pumps	16.6
Cabin Continuous Flow Systems.	15.5	Vane Pump, Wet and Dry Types.	16.6
Demand Flow Systems	15.6	Piston Pump.	16.7
Diluter-Demand	15.7	Turbine Engine Compressor	16.7
Pressure Demand.	15.8	Roots Type Blower.	16.8
Cockpit Demand Systems	15.8	Vacuum Pumps	16.8
Chemical Oxygen Systems	15.8	Submodule 16 Practice Questions	16.9
Electronic Pulse Demand Systems	15.9	Submodule 16 Practice Answers	16.10
Indication and Warnings	15.9	11.17 WATER/WASTE (ATA 38)..... 17.1	
Oxygen System Maintenance	15.10	Section A	17.1
Leak Testing Gaseous Oxygen Systems	15.10	Water/Waste Systems	17.1
Draining an Oxygen System	15.11	Water System Layout.	17.1
Purging an Oxygen System	15.11	Water Supply	17.1
Inspection of Masks and Hoses.	15.11	Water Distribution.	17.2
Replacement of Tubing, Valves, and Fittings	15.12	Water System Servicing.	17.2
Oxygen System Safety	15.12	Water System Draining	17.3
Submodule 15 Practice Questions	15.13	Toilet System Layout	17.3
Submodule 15 Practice Answers	15.14	Flushing	17.3
11.16 PNEUMATIC/VACUUM (ATA 36) 16.1		Lavatory Layout.	17.5
Section A	16.1	Servicing Lavatories.	17.5
Pneumatic Systems	16.1	Section B	17.5
High-pressure Pneumatic Systems	16.1	Corrosion	17.5
System Layout	16.1	Submodule 17 Practice Questions	17.7
System Components	16.1	Submodule 17 Practice Answers	17.8
Air Compressors	16.1	11.18 ONBOARD MAINTENANCE SYSTEMS (ATA 45)..... 18.1	
Relief Valves.	16.1	Central Maintenance Computers	18.1
Control Valves	16.1	BITE	18.3
Check Valves	16.2	Data Loading Systems.	18.3

TABLE OF CONTENTS

Electronic Library System	18.3
Printing	18.4
Structure Monitoring	18.4
Submodule 18 Practice Questions	18.5
Submodule 18 Practice Answers	18.6
11.19 INTEGRATED MODULAR AVIONICS (IMA) (ATA 42).....	19.1
Section A	19.1
Integration of Avionics	19.1
Digital Data Buses Reduce Wiring	19.2
Core Systems	19.3
Common Core Systems Concepts	19.3
Network Components	19.3
Section B	19.4
Typical System Layout	19.4
Boeing 777 Airplane Information Management System	19.4
Submodule 19 Practice Questions	19.7
Submodule 19 Practice Answers	19.8
11.20 CABIN SYSTEMS (ATA 44).....	20.1
Introduction	20.1
System Architecture, Operation and Control	20.1
In Flight Entertainment (IFE)	20.2
IFE Server	20.3
External Communication Systems	20.3
Wi-Fi Access	20.3
Flight Attendant's Panel	20.4
Director Interface Board	20.4
Cabin Network Server Interface and Hosting	20.4
Cabin Mass Memory Systems	20.4
Cabin Core Systems	20.5
Submodule 20 Practice Questions	20.7
Submodule 20 Practice Answers	20.8
11.21 INFORMATION SYSTEMS (ATA 46).....	21.1
Aircraft Information System	21.1
System Architecture, Operation and Control	21.2
The Airbus System	21.2
Network Server System (NSS)	21.2
Secure Communication Interface	21.2
Central Data Acquisition Module (CDAM)	21.2
Data Loading And Configuration Systems	21.2
Flight Deck Information System: Electronic Flight Bag	21.2
Boeing 777 EFB	21.2
Maintenance Information System	21.3
Passenger Cabin Information System	21.3
Miscellaneous Information System	21.3
Submodule 21 Practice Questions	21.5
Submodule 21 Practice Answers	21.6
Acronym Definitions	A.1

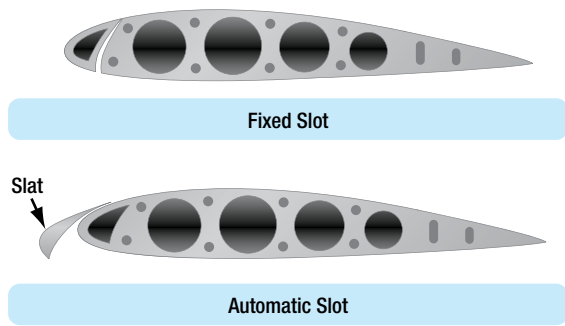


Figure 1-14. Wing slots.

SLATS

Another leading edge device which extends wing camber is a slat. Slats can be operated independently of the flaps with their own switch in the cockpit. Slats not only extend out of the leading edge of the wing increasing camber and lift, but most often, when fully deployed leave a slot between their trailing edges and the leading edge of the wing. [Figure 1-15] This increases the angle of attack at which the wing will maintain its laminar airflow, resulting in the ability to fly the aircraft slower and still maintain control.

FLAPS

Flaps are one such high lift device found on most aircraft. They are usually inboard on the wings' trailing edges adjacent to the fuselage. The flaps are lowered to increase the camber of the wings and provide greater lift and control at slow speeds. They enable landing at slower speeds and shorten the amount of runway required for takeoff and landing. The amount that the flaps extend and the angle they form with the wing can be selected from the cockpit. Typically, flaps can extend up to 45–50°. Figure 1-16 shows various aircraft with flaps in the extended position.

There are various kinds of flaps. [Figure 1-17] Plain flaps form the trailing edge of the wing when the flap is in the retracted position. The airflow over the wing continues over the upper and lower surfaces of the flap, making the trailing edge of the flap essentially the trailing edge of the wing. The plain flap is hinged so that the trailing edge can be lowered. This increases wing camber and provides greater lift.

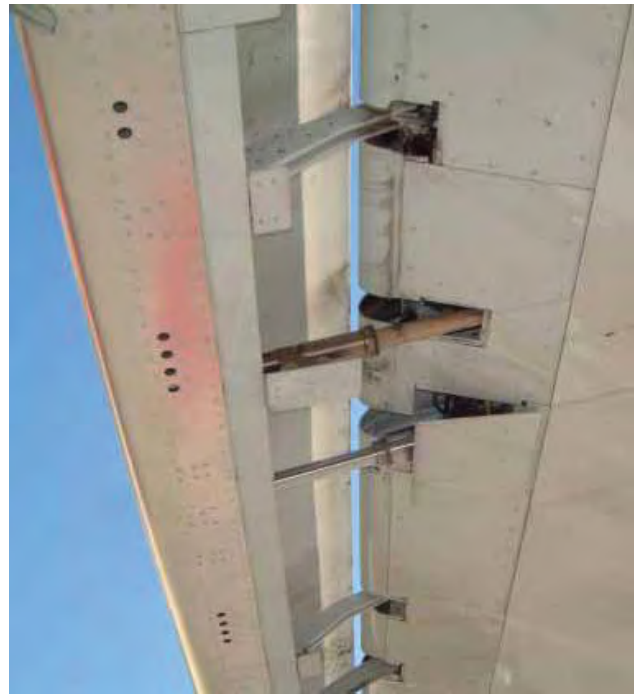


Figure 1-15. Air passing through the slot aft of the slat promotes boundary layer airflow on the upper surface at high angles of attack.

A split flap is normally housed under the trailing edge of the wing. It is usually just a braced flat metal plate hinged at several places along its leading edge. The upper surface of the wing extends to the trailing edge of the flap. When deployed, the split flap trailing edge lowers away from the trailing edge of the wing. Airflow over the top of the wing remains the same. Airflow under the wing now follows the camber created by the lowered split flap, increasing lift.

Fowler flaps not only lower the trailing edge of the wing when deployed but also slide aft, effectively increasing the area of the wing. This creates more lift via the increased surface area, as well as the wing camber. When stowed, the fowler flap typically retracts up under the wing trailing edge similar to a split flap. The sliding motion of a fowler flap can be accomplished with a worm drive and flap tracks.



Figure 1-16. Flap extension on large and small aircraft.

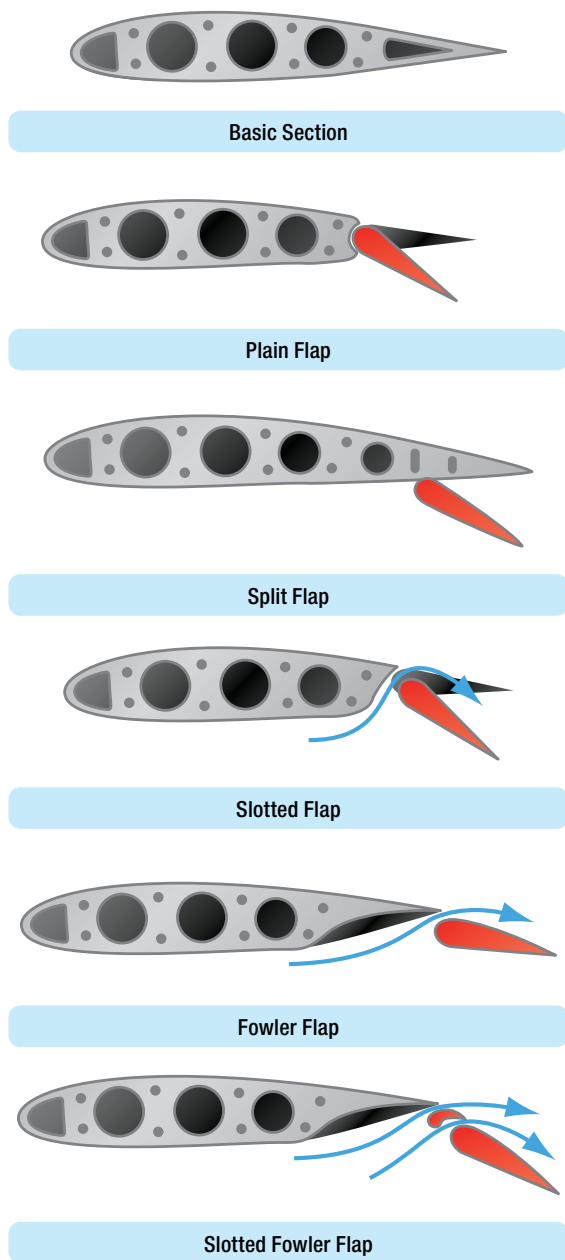


Figure 1-17. Types of flaps.

An enhanced version of the fowler flap is a set of flaps that actually contains more than one aerodynamic surface. **Figure 1-18** shows a triple slotted flap. In this configuration, the flap consists of a fore flap, a mid flap, and an aft flap. When deployed, each flap section slides aft on tracks as it lowers. The flap sections also separate leaving an open slot between the wing and the fore flap, as well as between each of the flap sections. Air from the underside of the wing flows through these slots. The result is that the flow on the upper surfaces is enhanced. The greater camber and effective wing area increase overall lift.

Heavy aircraft often have leading edge flaps that are used in conjunction with the trailing edge flaps. **Figure 1-19** While they are not installed or operate independently, their use with trailing edge flaps can greatly increase wing camber and lift. When stowed, leading edge flaps retract into the leading edge of the wing.

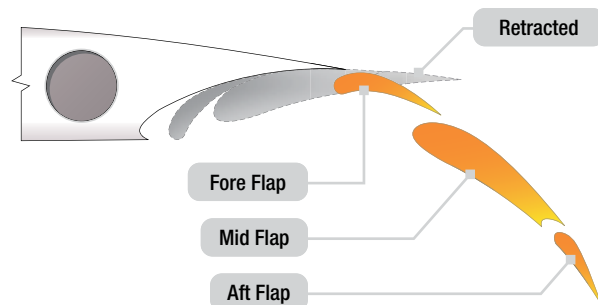


Figure 1-18. Triple slotted flap.

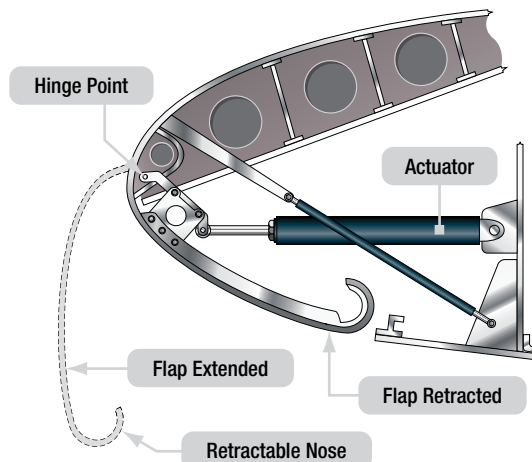


Figure 1-19. Leading edge flaps.

The differing designs of leading edge flaps essentially provide the same effect. Activation of the trailing edge flaps automatically deploys the leading edge flaps, which are driven out of the leading edge and downward, extending the camber of the wing.

FLAPERONS

Some aircraft are equipped with flaperons. **Figure 1-20** Flaperons are ailerons which can also act as flaps. Flaperons combine both aspects of flaps and ailerons. In addition to controlling the bank angle of an aircraft like conventional ailerons, flaperons can be lowered together to function much the same as a dedicated set of flaps. The pilot retains separate controls for ailerons and flaps. A mixer is used to combine the separate pilot inputs into this single set of control surfaces called flaperons.



Figure 1-20. Flaperons on a Boeing 787.

DRAG INDUCING DEVICES

The terms spoiler, lift dumper and speed brake are often used interchangeably. All are used to reduce lift and/or increase drag and have similar practical effects. One differentiation is that speed brakes are designed to create drag while spoilers and lift dumpers are designed to destroy lift. All have the effect of increasing rate of descent and of slowing an aircraft down, both in flight and after touchdown and thus assisting the aircraft ground brakes and helping to prevent their overheating.

Most often these devices are located on the upper surface of the wing. [Figure 1-21] An exception is the BAe146 where speed brakes operating exclusively as drag creation device deploys from the rear fuselage. [Figure 1-22]

In most airplanes the speed brake/ground spoiler function deploys automatically upon touchdown or upon deployment of the thrust reversers. However, some airplanes still require a manual deployment by the pilot.

SECONDARY AND AUXILIARY CONTROL SURFACES

TRIM TABS

The force of the air against a control surface during the high speed of flight can make it difficult to move and hold that control surface in the deflected position. Several different tabs are used to aid with these types of problems. [Figure 1-23] The table in



Figure 1-21. Spoilers fully deployed as speed brakes on an Embraer 190.



Figure 1-22. The BAe146 speed brake system can be deployed both in flight and after touchdown.

Figure 1-24 summarizes the various tabs and their uses. While in flight, it is desirable for the pilot to be able to take his or her hands and feet off of the controls and have the aircraft maintain its flight condition.

Trim tabs are designed to allow this. Most trim tabs are small movable surfaces located on the trailing edge of a primary flight control surface. A small movement of the tab in the direction opposite of the direction the flight control surface is deflected, causing air to strike the tab, in turn producing a force that aids 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 1-25. 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.

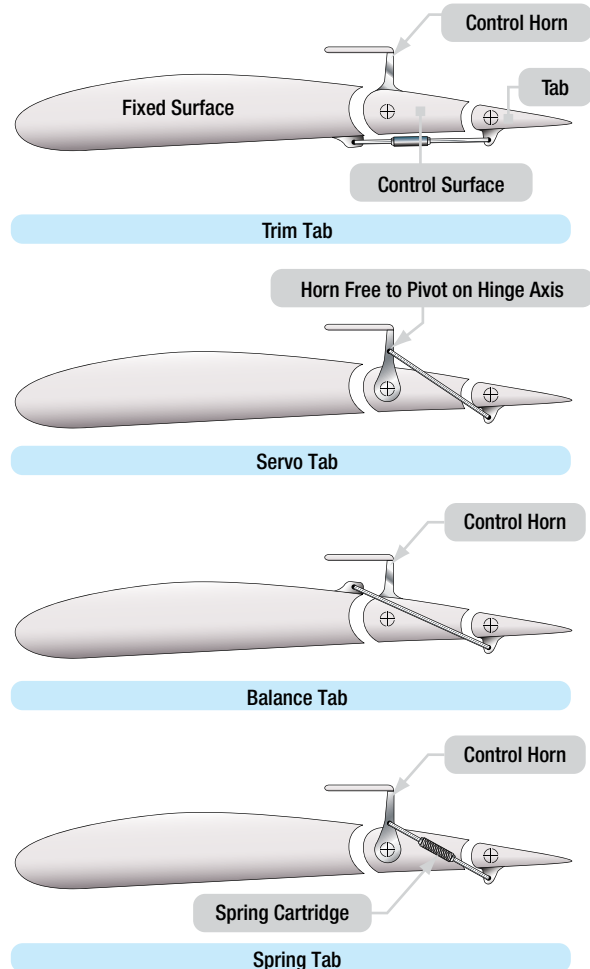


Figure 1-23. Types of trim tabs.

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 1-26]

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.

CONTROL SURFACE BIAS

When a control surface is in the neutral position, it is faired with the wing rudder or horizontal stabilizer and no effect on the aircraft's 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.

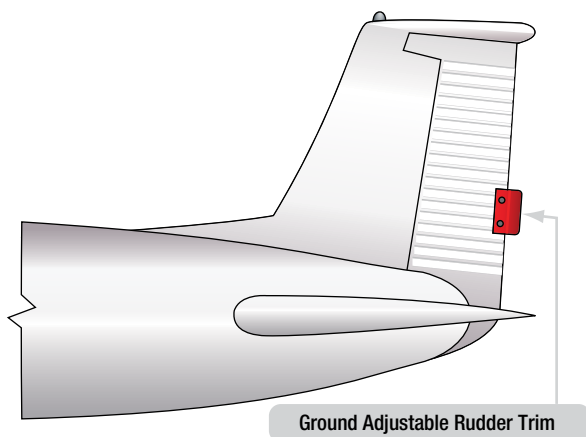


Figure 1-25. Example of a trim tab.

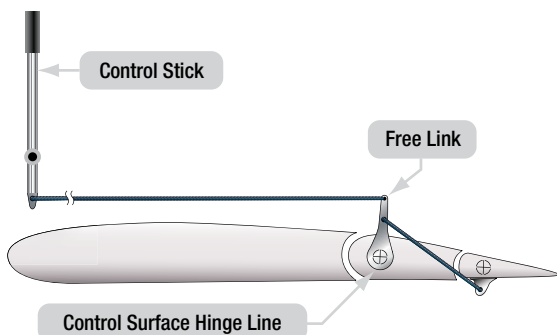


Figure 1-26. Servo tabs can be used to position flight control surfaces in case of hydraulic failure.

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 1-27] 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 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 1-28 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 1-29]

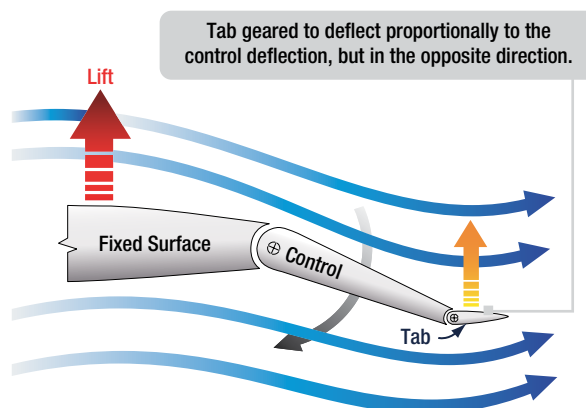


Figure 1-27. Balance tabs assist with forces needed to position control surfaces.

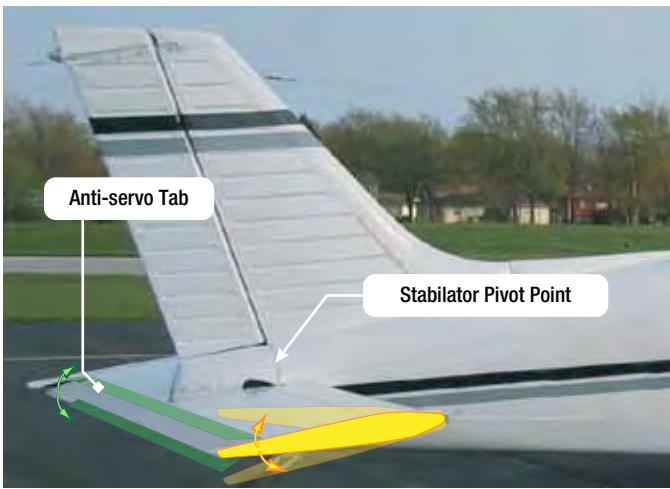


Figure 1-28. An Anti-servo tab moves in the same direction as the control tab. Shown here on a stabilator, it desensitizes the pitch control.



Figure 1-30. An aileron mass balance.

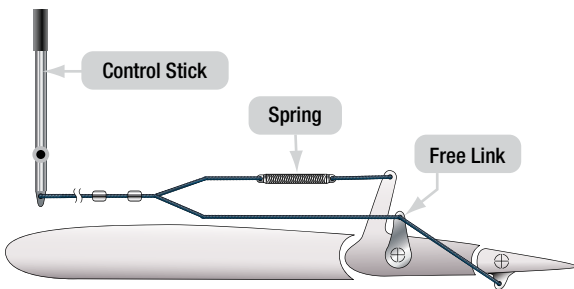


Figure 1-29. Many tab linkages have a spring tab that kicks in as the forces needed to deflect a control increase with speed and the angle of desired deflection.

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 1-30]

AERODYNAMIC BALANCE PANELS

Figure 1-31 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. [Figure 1-32]

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.

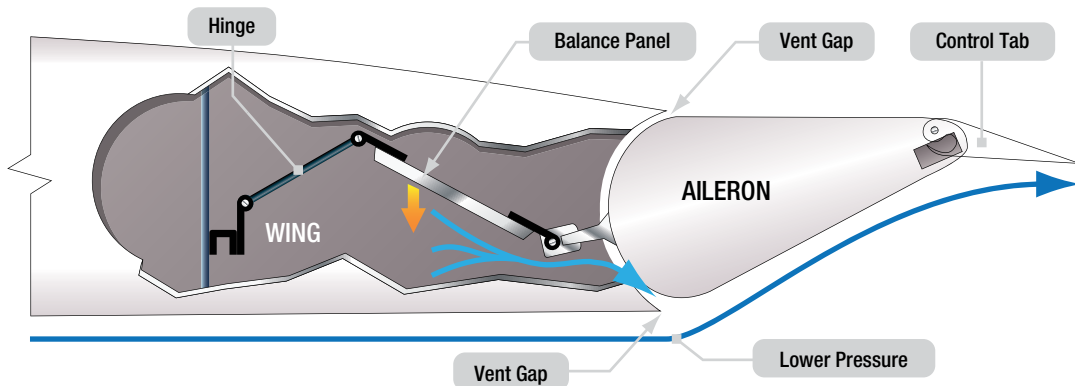


Figure 1-31. An aileron balance panel and linkage uses varying air pressure to assist in control surface positioning.