AIRCRAFT TECHNICAL BOOK COMPANY

B1

AVIATION MAINTENANCE TECHNICIAN CERTIFICATION SERIES

TURBINE AEROPLANE
STRUCTURES AND SYSTEMS

11

COMPLIANT WITH EASA EASA PART 66/147

EASA 2023-989 COMPLIANT

REVISION LOG

Update notices for this book will be available online at www.actechbooks.com/revisions.html
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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.
005.1	2024.05	Replaced Figures 1-39 and 5-69, adjusted small text errors throughout Module.
005.2	2025.01	Page viii and page 8.1 - Corrected Submodule 11.8(A) to level 3. Page 3.18 - Corrected term thermoplastics to thermoset polymers. Page 9.7 - Corrected the orientation of left side checknut. Page 12.16 - Replaced to improve Figure 12-27.

Module was reorganized based upon the EASA 2023-989 subject criteria. Enhancements included in this version 005.2 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.

MEASUREMENT STANDARDS

SI Units
The measurements used in this book are presented with the International System of Units (SI) standards in all cases except when otherwise specified by ICAO (for example, altitude expressed in feet or performance numbers as specified by a manufacturer). The chart below can be used should your studies call for conversions into imperial numbers.

Number Groups
This book uses the International Civil Aviation Organization (ICAO) standard of writing numbers. This method separates groups of 3 digits with a space, versus the European method by periods and the American method by commas.

For example, the number one million is expressed as:

ICAO Standard	1 000 000
European Standard	1.000.000
American Standard	1,000,000

Prefixes
The prefixes used in the table below form names of the decimal equivalents in SI units.

PREFIX AND SYMBOLS CHART

MULTIPLICATION FACTORS	PREFIX	SYMBOL
1 000 000 000 000 000 000 = 10^{18}	exa	E
1 000 000 000 000 000 = 10^{15}	peta	P
1 000 000 000 000 = 10^{12}	tera	T
1 000 000 000 = 10^{9}	giga	G
1 000 000 = 10^{6}	mega	M
1 000 = 10^{3}	kilo	k
100 = 10^{2}	hecto	h
10 = 10^{1}	deca	da
0.1 = 10^{-1}	deci	d
0.01 = 10^{-2}	centi	c
0.001 = 10^{-3}	milli	m
0.000 001 = 10^{-6}	micro	µ
0.000 000 001 = 10^{-9}	nano	n
0.000 000 000 001 = 10^{-12}	pico	p
0.000 000 000 000 001 = 10^{-15}	femto	f
0.000 000 000 000 000 001 = 10^{-18}	atto	a

COMMON CONVERSIONS CHART

IMPERIAL	TO	SI (METRIC)
Distance		
1 Inch	is equal to	2.54 Centimeters
1 Foot	is equal to	0.304 Meters
1 (Statute) Mile	is equal to	1.609 Kilometers
Weight		
1 Pound	is equal to	0.454 Kilograms
Volume		
1 Quart	is equal to	0.946 Liters
1 Gallon	is equal to	3.785 Liters
Temperature		
˚0 Fahrenheit	is equal to	(-)17.778 Celsius (˚C)
˚0 Fahrenheit	is equal to	255.37 Kelvin (K)
Area		
1 Square Inch	is equal to	6.451 Square Centimeters
1 Square Foot	is equal to	0.093 Square Meters
1 Square Mile	is equal to	2.59 Square Kilometers
Velocity		
1 Foot Per Second	is equal to	0.304 Meters Per Second
1 Mile Per Hour	is equal to	1.609 Kilometers Per Hour
1 Knot	is equal to	1.852 Kilometers Per Hour

SI (METRIC)	TO	IMPERIAL
Distance		
1 Centimeter	is equal to	0.394 Inches
1 Meter	is equal to	3.28 Feet
1 Kilometer	is equal to	0.621 Miles
Weight		
1 Kilogram	is equal to	2.204 Pounds
Volume		
1 Liter	is equal to	1.057 Quarts
1 Liter	is equal to	0.264 Gallons
Temperature		
˚0 Celsius (˚C)	is equal to	33.8˚ Fahrenheit
˚0 Kelvin (K)	is equal to	(-)437.87 Fahrenheit
Area		
1 Square Centimeter	is equal to	0.155 Square Inches
1 Square Meter	is equal to	10.764 Square Feet
1 Square Kilometer	is equal to	0.386 Square Miles
Velocity		
1 Meter Per Second	is equal to	3.281 Feet Per Second
1 Kilometer Per Hour	is equal to	0.621 Miles Per Hour
1 Kilometer Per Hour	is equal to	0.540 Knots

Pressure		
pounds per square inch (psi)	kiloPascals (kPa)	6.897
pounds per square inch (psi)	Pascals (Pa)	6.894

Qualification on basic subjects for each aircraft maintenance license category or subcategory is accomplished in accordance with the following matrix. Where applicable, subjects are indicated by an "**X**" in the column below the license heading.

EASA LICENSE CATEGORY CHART MODULE NUMBER AND TITLE		A1 Airplane Turbine	B1.1 Airplane Turbine	B1.2 Airplane Piston	B1.3 Helicopter Turbine	B1.4 Helicopter Piston	B2 Avionics
1	Mathematics	X	X	X	X	X	X
2	Physics	X	X	X	X	X	X
3	Electrical Fundamentals	X	X	X	X	X	X
4	Electronic Fundamentals		X	X	X	X	X
5	Digital Techniques, Electronic Instrument Systems	X	X	X	X	X	X
6	Materials and Hardware	X	X	X	X	X	X
7	Maintenance Practices	X	X	X	X	X	X
8	Basic Aerodynamics	X	X	X	X	X	X
9	Human Factors	X	X	X	X	X	X
10	Aviation Legislation	X	X	X	X	X	X
11	Aeroplane Aerodynamics, Structures and Systems	X	X				
12	Rotorcraft Aerodynamics, Structures and Systems				X	X	
13	Aircraft Aerodynamics, Structures and Systems						X
14	Propulsion						X
15	Gas Turbine Engine	X	X		X		
16	Piston Engine			X		X	
17	Propeller	X	X	X			

Basic knowledge requirments as outlined in Part-66, Appendix I

The knowledge level indicators are defined on 3 levels as follows:

Level 1

A familiarization with the principal elements of the subject.

Objectives:

a. The applicant should be familiar with the basic elements of the subject.
b. The applicant should be able to give a simple description of the whole subject, using common words and examples.
c. The applicant should be able to use typical terms.

Level 2

A general knowledge of the theoretical and practical aspects of the subject and an ability to apply that knowledge.

Objectives:

a. The applicant should be able to understand the theoretical fundamentals of the subject.
b. The applicant should be able to give a general description of the subject using, as appropriate, typical examples.
c. The applicant should be able to use mathematical formula in conjunction with physical laws describing the subject.
d. The applicant should be able to read and understand sketches, drawings and schematics describing the subject.
e. The applicant should be able to apply his knowledge in a practical manner using detailed procedures.

Level 3

A detailed knowledge of the theoretical and practical aspects of the subject and a capacity to combine and apply the separate elements of knowledge in a logical and comprehensive manner.

Objectives:

a. The applicant should know the theory of the subject and interrelationships with other subjects.
b. The applicant should be able to give a detailed description of the subject using theoretical fundamentals and specific examples.
c. The applicant should understand and be able to use mathematical formula related to the subject.
d. The applicant should be able to read, understand and prepare sketches, simple drawings and schematics describing the subject.
e. The applicant should be able to apply his knowledge in a practical manner using manufacturer's instructions.
f. The applicant should be able to interpret results from various sources and measurements and apply corrective action where appropriate.

PART 66 BASIC KNOWLEDGE REQUIREMENTS

SUBMODULE KNOWLEDGE DESCRIPTIONS		LEVEL
		B1
11.1	**Theory of Flight** (a) Aeroplane aerodynamics and flight controls Operation and effect of: — Roll control: ailerons and spoilers; — Pitch control: elevators, stabilators, variable incidence stabilizers and canards; — Yaw control, rudder limiters; — Elevons, ruddervators; — High-lift devices, slots, slats, flaps, flaperons; — Drag-inducing devices, spoilers, lift dumpers, speed brakes; — Trim tabs, servo tabs, control surface bias. (b) Aeroplane: other aerodynamic devices Operation and effect of: — Balance and antibalance (leading) tabs; — Spring tabs; — Mass balance, aerodynamic balance panels; — Effects of wing fences, saw tooth leading edges; — Boundary layer control using vortex generators, stall wedges or leading-edge devices.	 2 2
11.2	**Airframe Structures (ATA 51)** (a) General concepts: — Zonal and station identification systems; — Electrical bonding; — Lightning strike protection provisions. (b) Airworthiness requirements for structural strength: — Structural classification: primary, secondary, and tertiary; — Fail-safe, safe-life, damage-tolerance concepts; — Stress, strain, bending, compression, shear, torsion, tension, hoop stress, fatigue; — Drains and ventilation provisions; — System installation provisions. (c) Construction methods: — Stressed skin fuselage, formers, stringers, longerons, bulkheads, frames, doublers, struts, ties, beams, floor structures, reinforcement, skinning, anticorrosive protection, wing, empennage and engine attachments; — Structure assembly techniques: riveting, bolting, bonding; — Methods of surface protection, such as chromating, anodising, painting; — Surface cleaning; — Airframe symmetry: methods of alignment and symmetry checks.	 2 2 2
11.3 11.3.1 11.3.2 11.3.3 11.3.4 11.3.5	**Airframe Structures — Aeroplanes** **Fuselage, Doors, Windows (ATA 52/53/56)** (a) Construction principles: — Construction and pressurisation sealing; — Wing, stabiliser, pylon, and undercarriage attachments; — Seat installation; — Construction, mechanisms, operation; — Windows and windscreen construction and mechanisms. (b) Airborne towing devices (glider, banner, target). (c) Doors: — Doors and emergency exits: safety devices; — Cargo loading system. **Wings (ATA 57)** Construction; Fuel storage; Landing gear, pylon, control surface and high lift/drag attachments. **Stabilizers (ATA 55)** Construction; Control surface attachment. **Flight Control Surfaces (ATA 55/57)** Construction and attachments; Balancing — mass and aerodynamics. **Nacelles/Pylons (ATA 54)** Nacelles/pylons: — Construction; — Firewalls; — Engine mounts.	 2 1 2 2 2 2 2

SUBMODULE KNOWLEDGE DESCRIPTIONS		LEVEL
		B1
11.4	**Air Conditioning and Cabin Pressurization (ATA 21)**	
	(a) Pressurization systems; Cabin pressure controllers, control, and safety valves; Control and indication.	3
	(b) Air supply Sources of air supply including engine bleed, APU and ground cart; Distribution systems.	3
	(c) Air conditioning Air-conditioning systems; Air cycle and vapour cycle machines; Flow, temperature and humidity control system; Control and indication control valves.	3
	(d) Safety and warning devices. Protection and warning devices.	3
	(e) Heating and ventilation systems.	-
11.5	**Instruments/Avionics Systems**	
11.5.1	**Instrument Systems (ATA 31)** Pitot-static: Airspeed indicators, Vertical speed indicators, Altimeters; Gyroscopic: Gyroscopic principles, Artificial horizons, Attitude directors, Direction indicators, Horizontal situation indicators (HSI), Slip indicators, Turn indicators, Turn coordinators; Compass systems: Systems, Direct reading, Remote reading, Stall-warning systems and angle-of-attack indicating systems, Glass cockpit; Indications of other aircraft systems.	2
11.5.2	**Avionics Systems** Fundamentals of system layouts and operation of: Autoflight (ATA 22); Communication Systems (ATA 23): — Very High Frequency (VHF) communications, — High Frequency (HF) communications, — Satellite Communications (SATCOM), — Controller–pilot data link communications (CPDLC), — Audio systems, — Emergency Locator Transmitters (ELTs), — Cockpit Voice Recorder (CVR); Navigation systems (ATA 34): — Very high frequency omnidirectional range (VOR), — Automatic direction finder (ADF), — Instrument landing system (ILS), — Microwave landing system (MLS), — Flight director systems (FDSs), distance-measuring equipment (DME), — Area navigation (RNAV) systems, — Flight management systems (FMSs), — Satellite navigation systems, — Air traffic control transponder, secondary surveillance radar, — Traffic alert and collision avoidance system (TCAS), — Weather avoidance radar, — Radio altimeter, — Inertial navigation system (INS), — ARINC (Aeronautical Radio Incorporated) communication and reporting. Types and uses of avionics general test equipment.	1

SUBMODULE KNOWLEDGE DESCRIPTIONS		LEVEL
		B1
11.6	**Electrical Power (ATA 24)** — Installation and operation of batteries; — DC power generation; — AC power generation; — Emergency power generation; — Voltage regulation; — Power distribution; — Inverters, transformers, rectifiers; — Circuit protection; — External/ground power.	3
11.7	**Equipment and Furnishings (ATA 25)** (a) Emergency equipment: Emergency equipment requirements. (b) Cabin and cargo layout: — Seats, harnesses, and belts; — Cabin layout; — Equipment layout; — Cabin furnishing installation; — Galley installation; — Cargo handling and retention equipment; — Airstairs.	2 1
11.8	**Fire Protection (ATA 26)** (a) Fire and smoke detection system, and fire-extinguishing systems: — Fire and smoke detection and warning systems; — Fire-extinguishing systems; — System tests. (b) Portable fire extinguisher.	3 1
11.9	**Flight Controls (ATA 27)** (a) Primary and secondary flight controls: — Primary controls: aileron, elevator, rudder, spoiler; — Trim control, trim tabs; — High-lift devices; — System operation: manual; — Gust locks and gust lock systems; — Artificial feel, yaw damper, Mach trim, rudder limiter; — Stall-warning systems. (b) Actuation and protection: — Active load control; — Lift dump, speed brakes; — Hydraulic, pneumatic systems; — Stall-protection systems. (c) System operation: Electrical systems, fly-by-wire systems. (d) Balancing and rigging.	3 3 3 3
11.10	**Fuel Systems (ATA 28, ATA 47)** (a) Systems: — System layout; — Fuel tanks; — Supply systems. (b) Fuel handling: — Cross-feed and transfer; — Refuelling and defuelling. (c) Indication and warnings. (d) Special systems: — Dumping, venting, and draining; — Inert gas systems. (e) Balancing: Longitudinal balance fuel systems.	3 3 3 3 3

SUBMODULE KNOWLEDGE DESCRIPTIONS		LEVEL
		B1
11.11	**Hydraulic Power (ATA 29)**	
	(a) System description: System layout; Hydraulic fluids; Hydraulic reservoirs and accumulators; Filters; Power distribution.	3
	(b) System operation (1): Pressure generation: electric and mechanical; Pressure control; Indication and warning systems; Servicing.	3
	(c) System operation (2): Pressure generation: pneumatic; Emergency pressure generation; Interface with other systems.	3
11.12	**Ice and Rain Protection (ATA 30)**	
	(a) Principles: Ice formation, classification, and detection.	3
	(b) De-icing: De-icing systems: electrical, hot-air, pneumatic, chemical; Probe and drain heating.	3
	(c) Anti-icing: Anti-icing systems: electrical, hot-air, chemical.	3
	(d) Wipers: Wiper systems.	3
	(e) Rain-repellent systems.	3
11.13	**Landing Gear (ATA 32)**	
	(a) Description: Construction, shock absorbing; Tires.	3
	(b) Systems: Extension and retraction systems: normal and emergency; Indications and warnings; Wheels, brakes, antiskid, and autobraking; Steering.	3
	(c) Air–ground sensing.	3
	(d) Tail protection: Skids.	3
11.14	**Lights (ATA 33)** External: navigation, anticollision, landing, taxiing, ice; Internal: cabin, cockpit, cargo; Emergency.	3
11.15	**Oxygen (ATA 35)** System layout: Cockpit, cabin; Sources, storage, charging and distribution; Supply regulation; Indications and warnings.	3
11.16	**Pneumatic/Vacuum (ATA 36)**	
	(a) Systems: System layout; Sources: engine/APU (Auxiliary Power Unit), compressors, reservoirs, ground supply; Pressure control; Distribution; Indications and warnings; Interface with other systems.	3
	(b) Pumps: Pressure and vacuum pumps.	3
11.17	**Water/Waste (ATA 38)**	
	(a) Systems: Water system layout, supply, distribution, servicing and draining; Toilet system layout, flushing and servicing.	3
	(b) Corrosion: Corrosion aspects.	3

PART 66 BASIC KNOWLEDGE REQUIREMENTS

SUBMODULE KNOWLEDGE DESCRIPTIONS		LEVEL
		B1
11.18	**Onboard Maintenance Systems (ATA 45)** Central maintenance computers; Data-loading system; Electronic library system; Printing systems; Structure monitoring (damage-tolerance monitoring).	2
11.19	**Integrated Modular Avionics (IMA) (ATA 42)** (a) Overall system description and theory: Core system; network components; Functions that may be typically integrated in the integrated modular avionics (IMA) modules are, among others: Bleed management, air pressure control, air ventilation and control, avionics and cockpit ventilation control, temperature control, air traffic communication, avionics communication router, electrical load management, circuit breaker monitoring, electrical system BITE, fuel management, braking control, steering control, landing gear extension and retraction, tire pressure indication, oleo pressure indication, brake temperature monitoring, etc. (b) Typical system layout.	2 2
11.20	**Cabin Systems (ATA 44)** System architecture, operation, and control of systems for: — passenger in-flight entertainment; — communication within the aircraft (Cabin intercommunication data system (CIDS); — communication between the aircraft cabin and ground stations; — including voice, data, music, and video transmission. CIDS interface between cockpit/cabin crew and cabin systems. Data exchange between the different related line replaceable units (LRUs). Flight attendant panels (FAPs). Cabin network server (CNS) and interfaces with the following systems: — Data/radio communication; — Cabin core system (CCS); — In-flight entertainment system (IFES); — External communication system (ECS); — Cabin mass memory system (CMMS); — Cabin monitoring system (CMS); — Miscellaneous cabin systems (MCSs); and — Other systems. Cabin network server (CNS) hosting functions: — Access to predeparture/departure reports; — Email/intranet/internet access; passenger database; — In-flight entertainment system; — External communication system; — Cabin mass memory system; — Cabin monitoring system; — Miscellaneous cabin system.	2
11.21	**Information Systems (ATA 46)** System architecture, operation, and control of: — Storage and electronic library; — Updating; — Retrieving of digital information; — Air traffic and information management systems (ATIMS) and network server systems; — Aircraft general information system; — Flight deck information system; — Maintenance information system; — Passenger cabin information system; — Miscellaneous information systems; — Other linked systems.	2

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Figure 1-12. The Piaggio P180 includes a variable-sweep canard design, which provides longitudinal stability about the lateral axis.

aircraft. Canard designs include two types, one with a horizontal surface of about the same size as a normal aft tail design, and the other with a surface of the same approximate size and airfoil shape of the aft mounted wing known as a tandem wing configuration. Theoretically, the canard is considered more efficient because using the horizontal surface to help lift the weight of the aircraft should result in less drag for a given amount of lift.

YAW CONTROL DEVICES

RUDDERS

The rudder is the primary control surface that causes an aircraft to yaw or move about the vertical axis. This provides directional control and thus points the nose of the aircraft in the direction desired. Most aircraft have a single rudder hinged to the trailing edge of the vertical stabilizer. It is controlled by a pair of foot operated rudder pedals in the cockpit. When the right pedal is pushed forward, it deflects the rudder to the right which moves the nose of the aircraft to the right. The left pedal is rigged to simultaneously move left. When the left pedal is pushed forward, the nose of the aircraft moves to the left.

As with the other primary flight controls, the transfer of the movement of the cockpit controls to the rudder varies with the complexity of the aircraft. Many aircraft incorporate the directional movement of the nose or tail wheel into the rudder control system for ground operation. This allows the operator to steer the aircraft with the rudder pedals during taxi when the airspeed is not high enough for the control surfaces to be effective. Some large aircraft have a split rudder arrangement. This is actually two rudders, one above the other. At low speeds, both rudders deflect in the same direction when the pedals are pushed. At higher speeds, one of the rudders becomes inoperative as the deflection of a single rudder is aerodynamically sufficient to maneuver the aircraft.

RUDDER LIMITERS

In flight, most large aircraft oscillate slightly from side to side. Yaw dampener units automatically detect this movement and send signals to the hydraulic power control unit (PCU) that moves the rudder so that it can correct for these yaw oscillations. Similarly, rudders are known to deflect without being commanded to do so by the flight crew. Again, the yaw dampener is designed to correct the fluctuations by signaling the PCU. However, too large of an involuntary deflection to a rudder can cause a loss of control of the aircraft.

A rudder limiter is fitted to many aircraft to prevent any more than a few degrees of involuntary motion of the rudder. Essentially, it limits the movement unless it is commanded from the flight deck.

ELEVONS AND RUDDERVATORS

ELEVONS

Elevons perform the combined functions of the ailerons and the elevator. [**Figure 1-13**] They are typically used on aircraft that have no true separate empennage such as a delta wing or flying wing aircraft.

They are installed on the trailing edge of the wing. When moved in the same direction, the elevons cause a pitch adjustment. When moved in opposite directions, the aircraft rolls. Elevons may also move differentially in the same direction causing adjustments to roll and pitch. The control yoke or stick activated elevon movement through a mechanical or electronic mixing device.

RUDDERVATORS

A ruddervator combines the action of the rudder and elevator. [**Figure 1-14**] This is possible on aircraft with V–tail empennages where the traditional horizontal and vertical stabilizers do not exist. Instead, two stabilizers angle upward and outward from the aft fuselage in a "V" configuration. Each contains a movable

Figure 1-13. Elevons.

Figure 1-14. Ruddervator.

and formers as used in the monocoque design but, additionally, the skin is reinforced by longitudinal members called longerons. Longerons usually extend across several frame members and help the skin support primary bending loads. They are typically made of aluminum alloy either of a single piece or a built up construction.

Stringers are also used in the semimonocoque fuselage. These longitudinal members are typically more numerous and lighter in weight than the longerons. They come in a variety of shapes and are usually made from single piece aluminum alloy extrusions or formed aluminum. Stringers have some rigidity but are chiefly used for giving shape and for attachment of the skin. Stringers and longerons together prevent tension and compression from bending the fuselage. [**Figure 2-11**]

Other bracing between the longerons and stringers can also be used. Often referred to as web members, these additional support pieces may be installed vertically or diagonally. It must be noted that manufacturers use different nomenclature to describe structural members. For example, there is often little difference between some rings, frames, and formers.

One manufacturer may call the same type of brace a ring or a frame. Manufacturer instructions and specifications for a specific aircraft are the best guides.

The semimonocoque fuselage is constructed primarily of alloys of aluminum and magnesium, although steel and titanium are sometimes found in areas of high temperatures. Individually, no one of the aforementioned components is strong enough to carry the loads imposed during flight and landing. But, when combined, those components form a strong, rigid framework. This is accomplished with gussets, rivets, nuts and bolts, screws, and even friction stir welding. A gusset is a type of connection bracket that adds strength. [**Figure 2-12**]

To summarize, in semimonocoque fuselages, the strong, heavy longerons hold the bulkheads and formers, and these, in turn, hold the stringers, braces, web members, etc. All are designed to be attached together and to the skin to achieve the full strength benefits of semimonocoque design. It is important to recognize that the metal skin or covering carries part of the load. The fuselage skin thickness can vary with the load carried and the stresses sustained at a particular location.

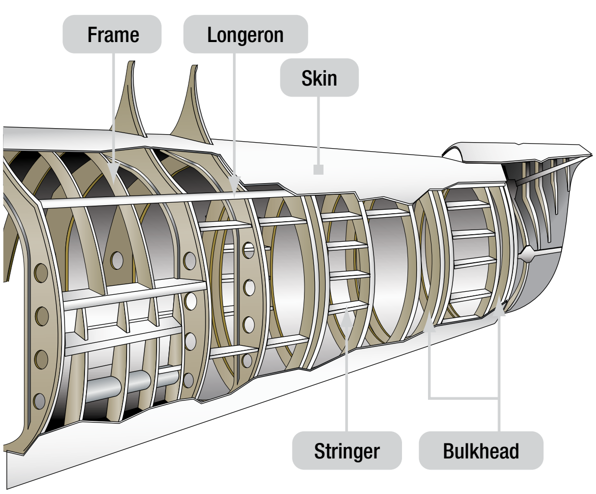

Figure 2-11. The fuselage terminates at the tail cone with similar but more light weight construction.

The advantages of the semimonocoque fuselage are many. The bulkheads, frames, stringers, and longerons facilitate the design and construction of a streamlined fuselage that is both rigid and strong. Spreading loads among these structures and the stressed skin means no single piece is failure critical.

This means that a semimonocoque fuselage, because of its stressed skin construction, may withstand considerable damage and still be strong enough to hold together.

FUSELAGE COMPONENTS

FRAMES
Frames and stringers make up the basic skeleton of the fuselage. Frames are generally open rings which form the basic shape. They are connected continuously around their peripheries to the fuselage shell by stringers or longerons to form the rigid structure. **Figure 2-13** depicts these various components of a fuselage.

FORMERS
Formers are used in the construction of aircraft fuselage, of which a typical fuselage has a series from the nose to the empennage, typically perpendicular to the longitudinal axis of the aircraft.

STRINGERS AND LONGERONS
Stringers, (sometimes referred to as longerons), run lengthwise along an airplane's fuselage or span wise of a wing. Their purpose is to serve as structural components that transfer loads and stresses from the aircraft's skin to the formers. Generally, they are attached between formers and bulkheads and are more numerous than longerons and spaced more closely together.

BULKHEADS
Bulkheads separate sections of the aircraft. The first bulkhead function is to provide structural support to the fuselage, particularly where the fuselage attaches to other structures such as the wings. A second function is to separate pressurized from non-pressurized sections of the fuselage. [**Figure 2-14**]

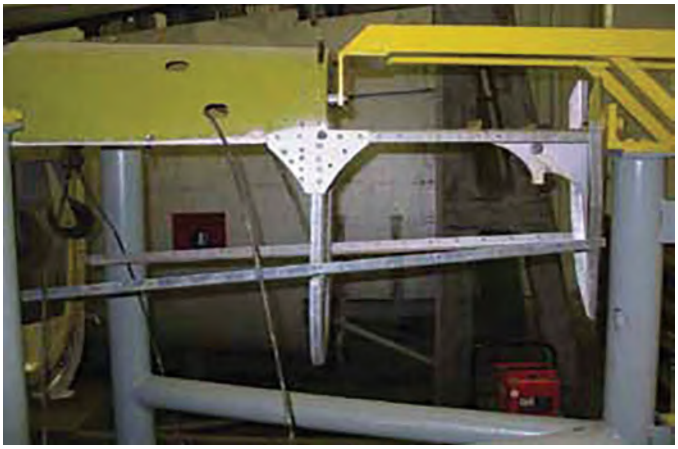

Figure 2-12. Gussets are used to increase strength.

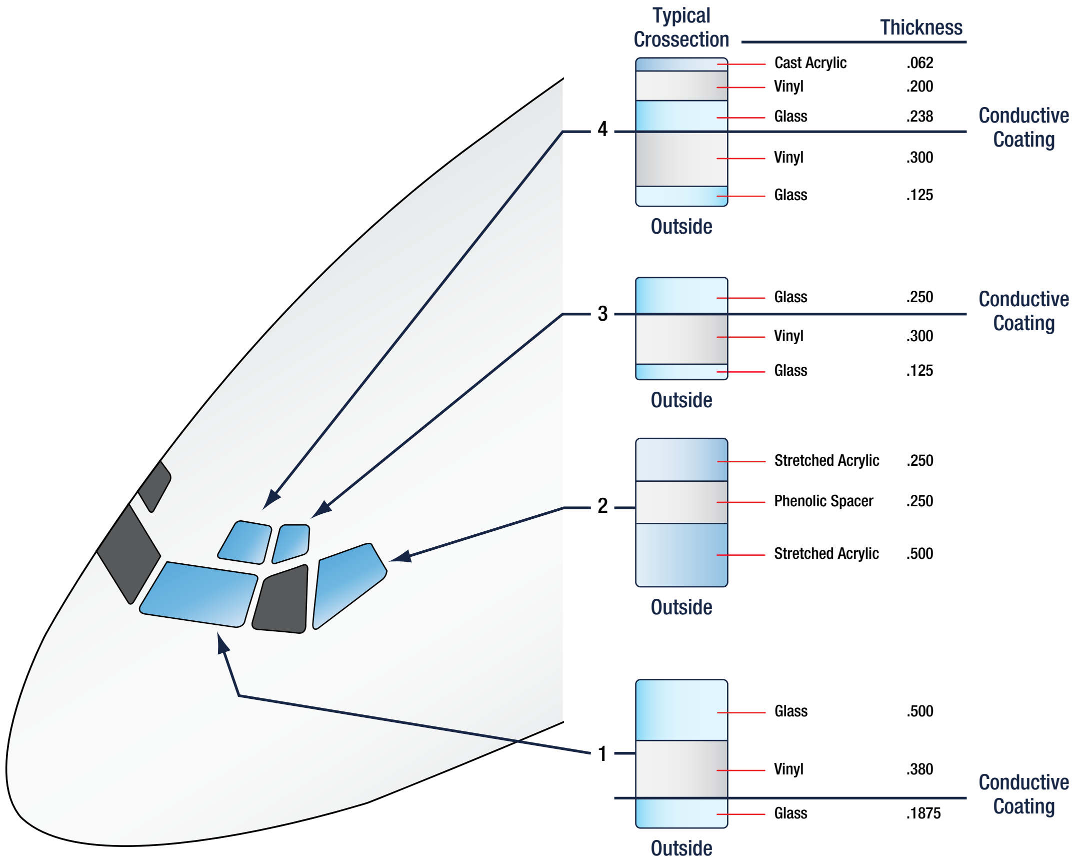

Figure 3-4. Flight deck window laminations.

Figure 3-5. A Boeing 737 sliding window assembly.

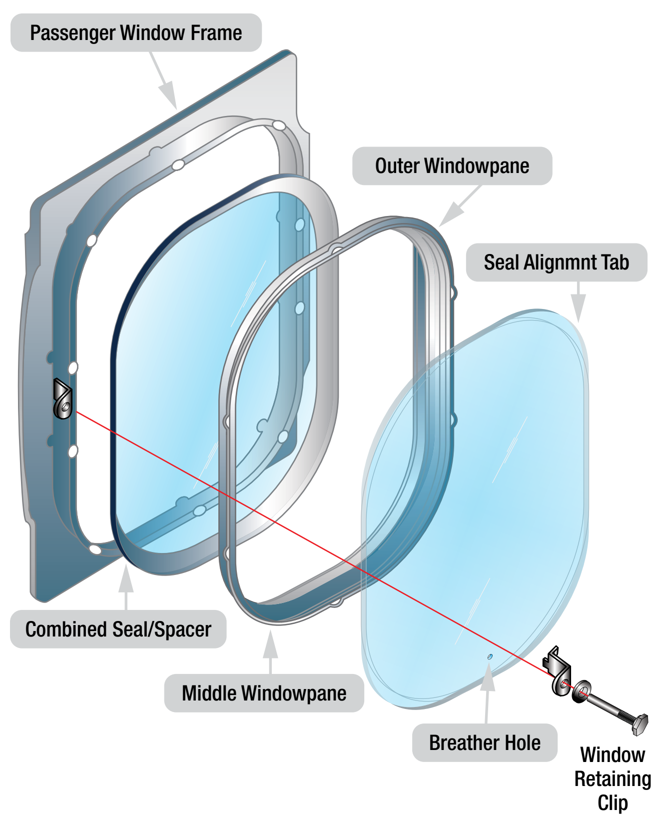

Figure 3-6. Middle and outer passenger cabin windows, seal and window frame.

ATTACHMENT

Passenger cabin windows are fixed plug type windows. They are installed from inside the aircraft between fuselage frame members with a single seal that accepts both the middle and outer window panes. [**Figure 3-6**]

Retaining clips hold the assembly in place against the window frame in the fuselage skin. The middle and outer window panes are each able to withstand the forces of pressurization so if one breaks or is damaged, cabin pressurization is not lost. As stated, flight deck window assemblies are bolted to the fuselage structure.

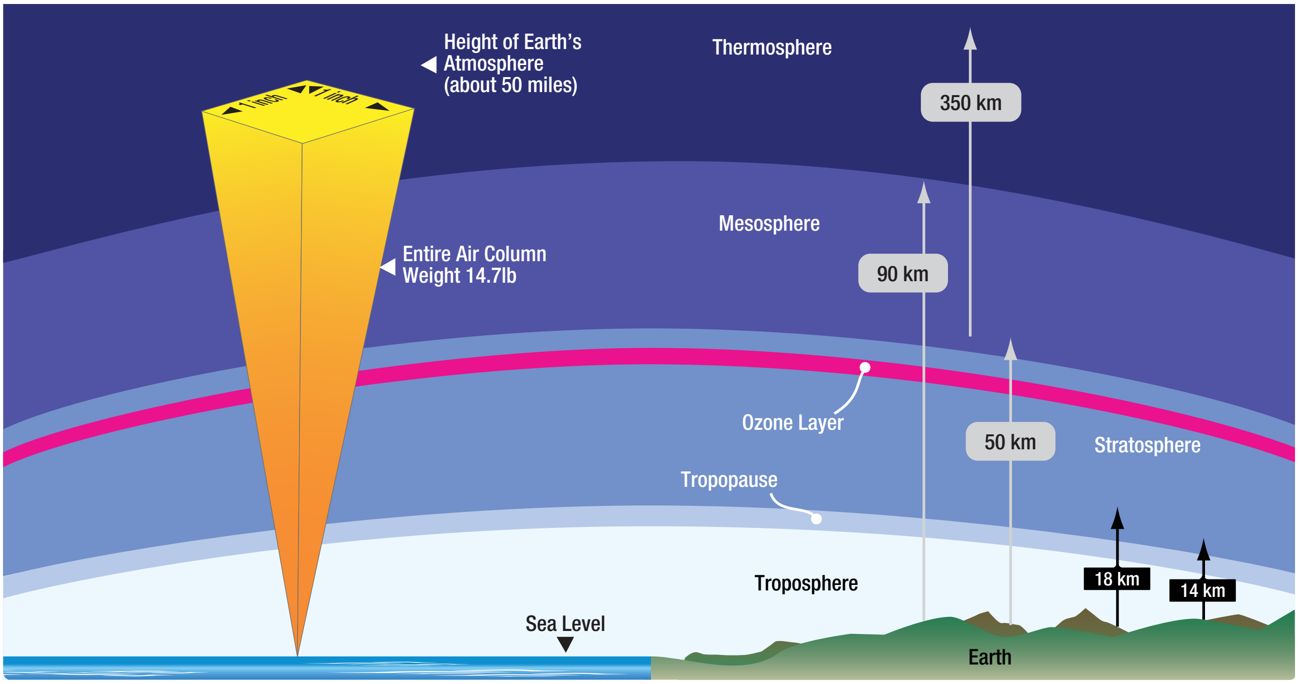

Figure 4-1. The weight exerted by a 1 square inch column of air stretching from sea level to the top of the atmosphere is what is measured when it is said that atmospheric pressure is equal to 14.7 pounds per square inch.

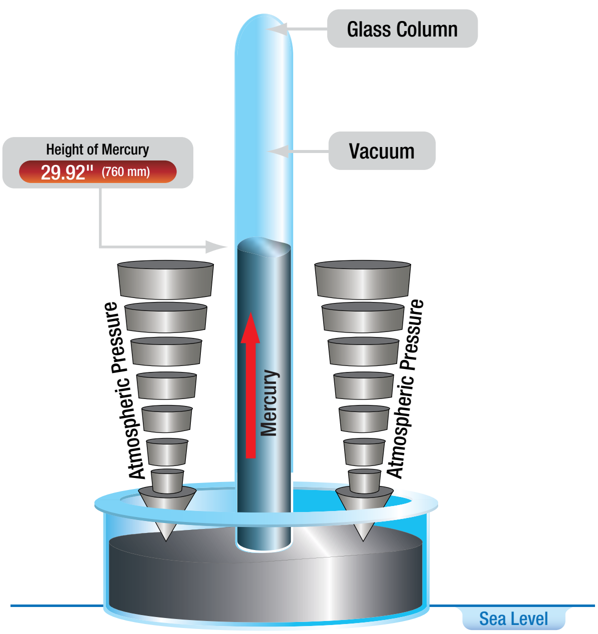

Figure 4-2. The weight of the atmosphere pushes down on the mercury in the reservoir of a barometer, which causes mercury to rise in the column. At sea level, mercury is forced up into the column approximately 29.92 inches. Therefore, it is said that barometric pressure is 29.92 inches of mercury at sea level.

constant temperature of -57°C or -69°F. Above the tropopause lies the stratosphere. Temperature increases with altitude in the stratosphere to near 0°C before decreasing again in the mesosphere, which lies above it.

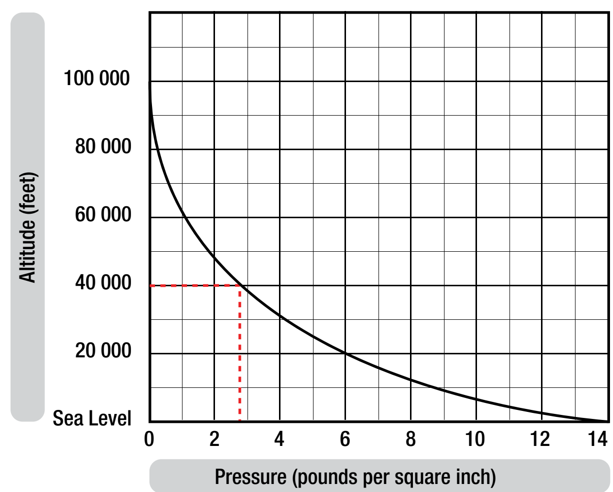

Figure 4-4. Atmospheric pressure decreasing with altitude. At sea level the pressure is 14.7 psi, while at 40 000 feet, as the dotted lines show, the pressure is only 2.72 psi.

Atmospheric Pressure

Standard atmospheric pressure at sea level is also known as 1 atmosphere, or 1 atm. The following measurements of standard atmospheric pressure are all equal to each other.

1 atm (atmosphere) = 14.7 psi (pounds per square inch) = 29.92 in Hg (inches of mercury) = 1013.2 hPa (or 101325 newtons per square meters) = 1013.2 mb (millibars) = 760 mm Hg (millimeters of mercury)

Figure 4-3. Various equivalent representations of atmospheric pressure at sea level.

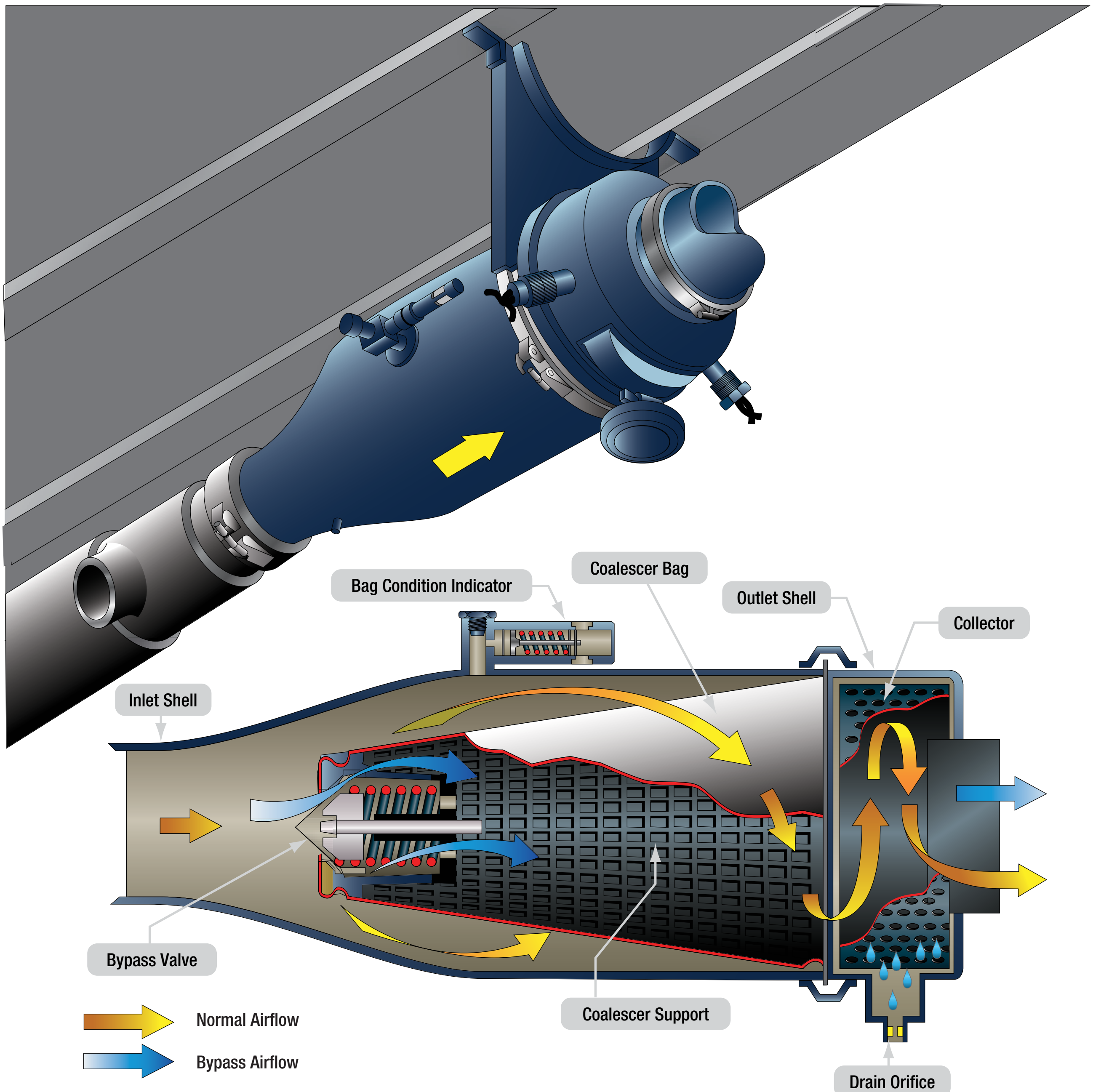

Figure 4-30. A water separator coalesces and removes water by swirling the air/water mixture from ACM expansion turbine. Centrifugal force sends the water to the walls of the collector where it drains from the unit.

gaseous refrigerant flows through tubing to a condenser. The condenser is like a radiator comprised of a great length of tubing with fins attached to promote heat transfer. Outside air is directed over the condenser. The temperature of the refrigerant inside is higher than the ambient air temperature, so heat is transferred from the refrigerant to the outside air. The amount of heat given off is enough to cool the refrigerant and to condense it back to a high-pressure liquid. It flows through tubing and back into the receiver dryer, completing the vapor cycle.

There are two sides to the vapor cycle air conditioning system. One accepts heat and is known as the low side. The other gives up heat and is known as the high side. The low and high refer to the temperature and pressure of the refrigerant. As such, the compressor and the expansion valve are the two components that separate the low side from the high side of the cycle. [**Figure 4-34**] Refrigerant on the low side is characterized as having low pressure and temperature. Refrigerant on the high side has high-pressure and temperature.

VAPOR CYCLE AIR CONDITIONING SYSTEM COMPONENTS

By examining each component in the vapor cycle air conditioning system, greater insight into its function can be gained.

REFRIGERANT

For many years, dichlorodifluoromethane (R12) was the standard refrigerant used in aircraft vapor cycle air conditioning systems. Some of these systems remain in use today. R12 was found to have a negative effect on the environment; in particular, it