

27.1 Pneumatic Systems and Air Sources

- Pneumatic systems use high-volume, low-pressure air to operate various aircraft services like
- air conditioning, pressurization, and anti-icing. The air can come from several sources:
- ☐ Engine Bleed Air (Most Common): Hot, high-pressure air is bled from the compressor stages of the gas turbine engines. A system of valves (High Pressure Shut-Off Valve, Bleed Air Control Valve) controls which compressor stage (LP or HP) is used, depending on engine RPM.
- ☐ Auxiliary Power Unit (APU): An APU can provide bleed air on the ground.
- ☐ Ground Power Unit (GPU): A ground-based cart can supply air for engine starting and system checks.

27.2 Air Conditioning

- The air conditioning system (often called the "packs") cools the hot bleed air to a comfortable temperature for the cabin. The most common method is Air Cycle Cooling.
- ☐ Bootstrap System: Hot bleed air passes through a heat exchanger (cooled by outside ram air). This pre-cooled air then drives a compressor, which increases its pressure and temperature. It passes through a second heat exchanger before expanding rapidly across a turbine. This rapid expansion causes a massive temperature drop, providing very cold air for the cabin. The turbine's work is used to help drive the compressor, "pulling itself up by its own bootstraps."
- ☐ Temperature Control: The final cabin temperature is achieved by mixing the cold air from the packs with a small amount of hot, un-cooled bleed air via a trim air valve. This allows for different temperature zones within the cabin.
- ☐ Air Distribution: Conditioned air is distributed through the cabin and flight deck. A portion of the cabin air is often re-circulated by fans to improve efficiency.

27.3 Pressurization

- Pressurization maintains a safe and comfortable "cabin altitude" (typically 8,000 ft or lower)
- while the aircraft flies at high altitudes.
- ☐ Principle of Operation: The air conditioning packs supply a constant mass flow of air into the cabin. The system controls the cabin pressure by modulating the rate at which this air is allowed to escape through one or more outflow valves.
- To increase cabin pressure (or decrease cabin altitude), the outflow valve closes slightly.
- To decrease cabin pressure (or increase cabin altitude), the outflow valve opens slightly.
- ☐ System Components and Safety:
- Outflow Valve(s): The primary pressure regulating valves.
- Safety Valves: Protect the fuselage from over-pressurization. An outward relief valve prevents the cabin pressure from exceeding the outside pressure by a set limit (the max differential pressure). An inward relief valve prevents the outside pressure from exceeding the cabin pressure (e.g., during a rapid descent).
- Dump Valve: Allows the crew to rapidly depressurize the aircraft in an emergency.
- ☐ Modes of Operation: The pressurization controller operates automatically through different phases of flight:
- On Ground: Outflow valve is fully open.
- Takeoff: The aircraft is pre-pressurized slightly to avoid a pressure surge on rotation.
- Climb/Descent: The controller maintains a comfortable rate of change of cabin altitude (e.g., 500 ft/min up, 300 ft/min down).
- Cruise: The controller maintains a constant cabin altitude until the maximum differential pressure is reached, then maintains that constant differential.