DOCUMENT NUMBER
GSM-G-CPL.009

DOCUMENT TITLE

AIRFRAME AND SYSTEMS
CHAPTER 7: PRESSURISATION SYSTEMS

Version 1.0
September 2012

CONTENTS .... PAGE

INTRODUCTION

Light aircraft and older medium sized piston engine aircraft that cruise at altitudes up to 10,000 ft are normally not pressurised as the human body can breathe normally at this altitude and not suffer any effects from the lack of oxygen.

Modern turboprops and jet powered aircraft cruise at much higher altitudes than 10,000 ft and of course need to be pressurised to maintain a suitable atmospheric pressure inside the cabin for the crew and passengers.

Obviously a sea level atmosphere inside the cabin would be ideal but this would require an extremely strong aircraft structure due to the resultant large differential pressure. A structure such as this would be too heavy to be economically viable.

Aircraft manufacturers therefore construct the aircraft fuselage so that it contains an area strong enough to achieve a cabin atmosphere of 8,000 ft when the aircraft is operating at its maximum cruising altitude. The containment area is commonly referred to as the pressurised hull of the aircraft. At 8000 ft cabin altitude the pressure difference between the inside and the outside of the pressurised hull is approximately 8.0 to 9.0 PSI depending on the aircraft manufacturer.

The percentage of oxygen in the atmosphere remains fairly constant at 21% as atmospheric pressure decreases, so from the human body perspective, at 8000 ft the actual pressure of oxygen has only decreased slightly from 3.06 PSI at sea level to 2.29 PSI at 8,000 ft.

<u>It is therefore generally accepted that 8,000 ft is an ideal maximum cabin altitude for passenger comfort and aircraft structural strength considerations.</u>

For interest only, the latest aircraft such as the B787 Dreamliner and the Airbus 380 are able to cruise at maximum altitude with a much lower cabin altitude (approximately 5,500-6,000 ft). This increases passenger comfort as the oxygen pressure is increased but requires a stronger fuselage structure to withstand the higher differential pressure.

In aircraft that are pressurised the incoming compressed air enters the cabin via the air-conditioning systems and exits through controllable outflow valves. The restriction of the outgoing airflow by these controllable valves is the method by which cabin pressurisation occurs. Refer to Figure 7-1.

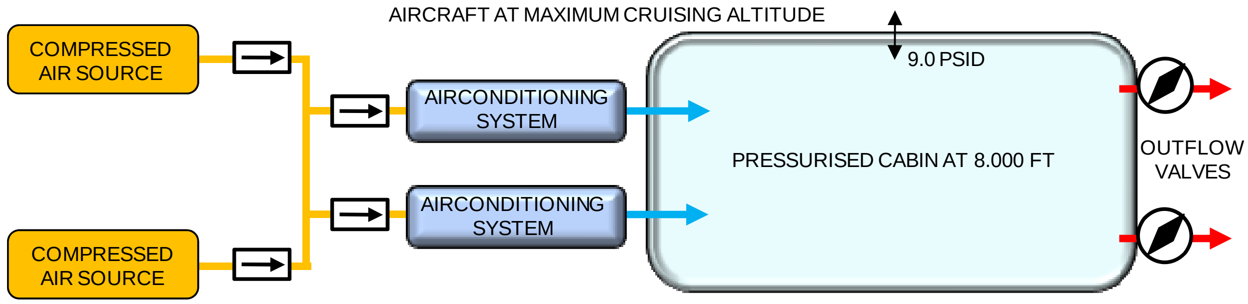


Figure 7-1 Aircraft Pressurisation

In most aircraft, pressurisation of the cabin begins during the take-off roll and finishes at touchdown and landing rollout. The pressurisation system follows the altitude profile of the aircraft during the flight, maintaining a proportionally lower cabin altitude but never exceeding 8000 ft. Refer to Figure 7-2.

In modern aircraft the combination of the air-conditioning and pressurisation systems is commonly referred to as the Environmental Control System (ECS). The control panel in the cockpit will likely be named the ECS or AIR Panel and will contain the controls for both systems. This Chapter however, will focus only on the pressurisation component of the ECS.

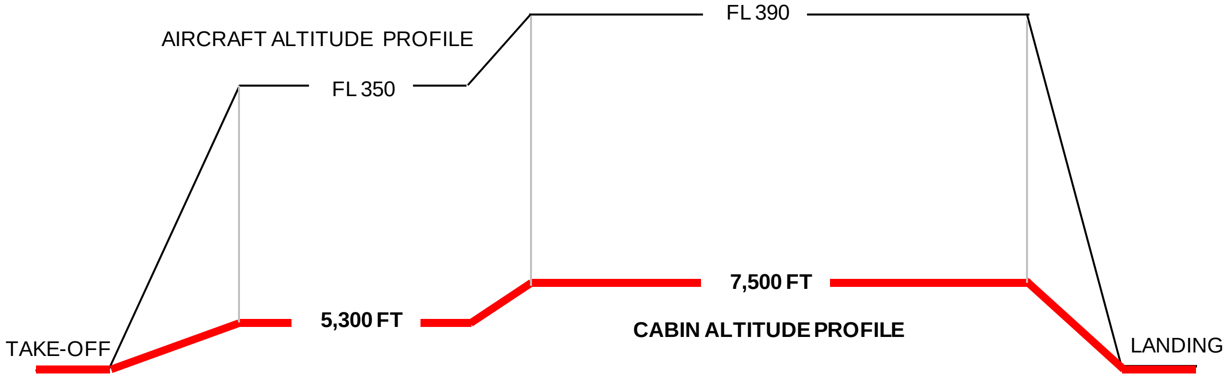


Figure 7-2 Aircraft Pressurisation Profile

PRESSURISATION CONSIDERATIONS AND REGULATIONS

HUMAN CONSIDERATIONS

The human body requires a continuous supply of oxygen, the quantity varying with the amount of physical effort. At sea level, atmospheric pressure oxygen is forced into the bloodstream. As atmospheric pressure decreases, less oxygen is forced into the bloodstream, and this can create a serious problem known as HYPOXIA.

This effect can be felt at altitudes above 10,000 ft, although at this altitude they pose no serious threat to human function other than a feeling of tiredness.

As altitude increases to 18,000 ft the full effects of hypoxia are evident, with a dulling of all senses. As altitude increases above this height, the phenomenon known as ANOXIA is apparent, with symptoms such as a loss of hearing, and eyesight, muscle spasms coupled with general weakness and sickness, and total unconsciousness eventually occurs.

At an altitude of 25,000 ft unconsciousness occurs after approximately six minutes, while at 40,000 ft that time is reduced to twelve seconds, followed quickly by death.

Another fact that needs to be understood, is that the lungs require a minimum oxygen pressure to enable the oxygen to diffuse through the tissue of the lungs and pass the red corpuscles into the blood stream.

The minimum atmospheric pressure to maintain life in this regard is 2.7 PSI, the equivalent atmospheric pressure being 40,000 ft, even if 100% pure oxygen is being breathed.

Experience has shown that the human body experiences no discomfort due to the effects of hypoxia at altitudes of 8,000 feet. It is therefore generally accepted that 8,000 feet is the ideal maximum cabin height for passenger comfort.

Another important consideration is the rate at which the human body can accept altitude or pressure changes. Rapid changes in altitude on the human body can cause physical pain and discomfort, ranging from expansion of gases in the abdomen, sickness and ear pain to mild effects of the bends and pain in joints.

The most common problems are associated with the ear. As the Eustachian Tube is of limited size it imposes restrictions on the air flowing inwards more than the air flowing outwards. This means that if cabin altitude is decreased too rapidly and pressure is not equalised in the ear, severe pain and damage to the eardrum can occur.

<u>It has been shown that cabin rates of change of 500 fpm ascending, and 300 fpm descending are acceptable for passenger comfort.</u> Rates of change greater than these may cause discomfort to some passengers.

STRUCTURE CONSIDERATIONS

Sea level pressure is 14.7 PSI. At 40,000 ft it has decreased to 2.72 PSI. This means that an aircraft flying at 40,000 ft with a cabin altitude of 8,000 ft (10.92 PSI) has a pressure differential of 8.2 PSI between inside and outside pressures.

As is normal in aviation there is a safety margin built into the airframe of the pressure hull, this being 1.33 times the maximum differential, which in this case would increase the maximum pressure that the airframe (B747 Classic) could withstand to 10.9 PSI.

For interest, consider the pressure on the main cabin door of an average commercial airliner. The door usually measures approximately 6 ft x 3 ft (72 in x 36 in or 2,592 sq/in). The pressure on the door with only 1 PSI differential between inside and outside is 1.16 tons. With 8.8 PSID the pressure is about 10.2 tons!

The pressurisation system of the aircraft is designed to maintain the hull differential pressure within the limits of 0 to 9.0 PSID but provision must also be made to protect the hull structure from dangerous over or under pressure. Dual independent over and under pressure safety relief valves ensure this protection. Refer to Figure 7-3.

Because aircraft are subject to continuous cycles of being pressurised and unpressurised during the course of each flight, over time the aircraft hull becomes fatigued or weakened due to the continual expansion and contraction of the structure. This can lead to loose rivets and cracks or tears in the aluminium skin. It is important that these cycles are recorded, and detailed inspections carried out in accordance with the manufacturer's recommendations

All pressurised aircraft are given a maximum number of "pressurisation cycles" and when this is reached major inspection and repair must be conducted before more cycles can be allocated. For interest a B737-200 cycle life is 75,000.

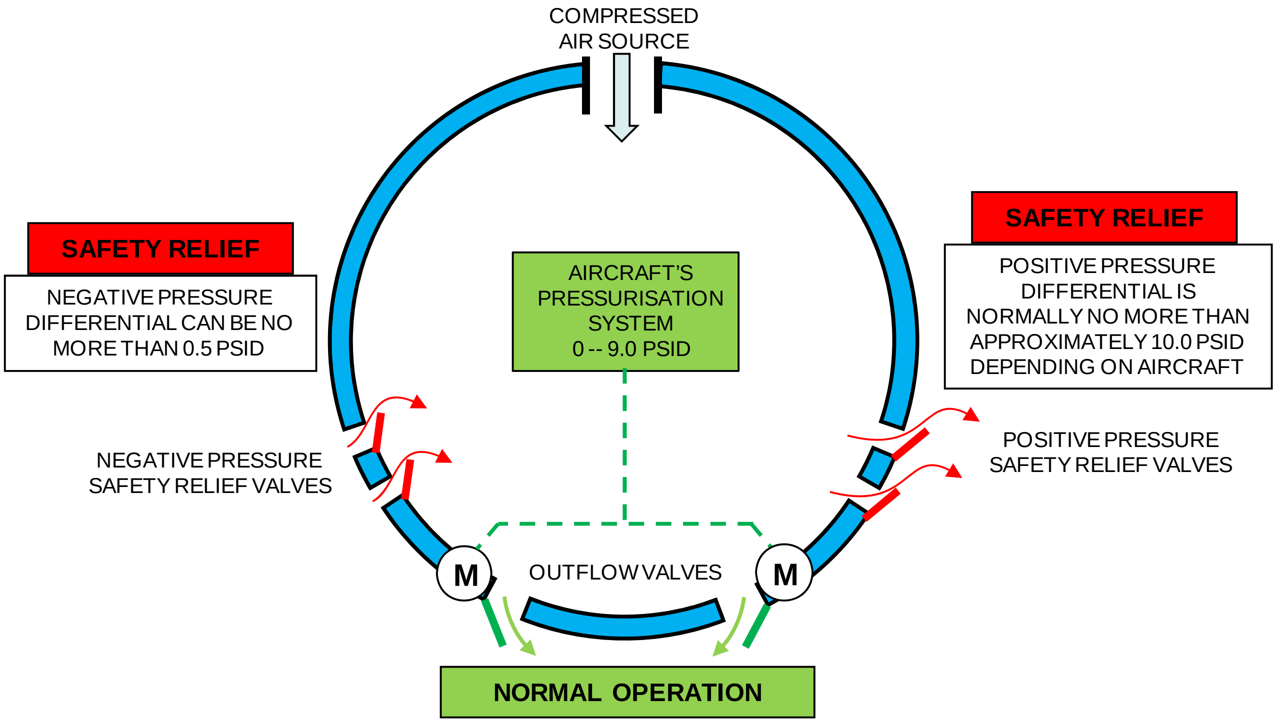


Figure 7-3 Pressurised Hull - Safety Reliefs

The pressurised hull structure whilst being basically tubular has ends and other sections that are joined to the unpressurised areas of the aircraft, these joints require strengthened walls or floors and are referred to as pressure bulkheads. As not all areas of an aircraft are pressurised there will be numerous pressure bulkheads as shown in Figure 7-4.

The forward and aft pressure bulkheads are the forward and aft limits of the pressurised cabin. They are usually located forward of the rudder pedals and at the rear of the passenger compartment. A pressure bulkhead is the joint between pressurised and unpressurised areas of an aircraft structure.

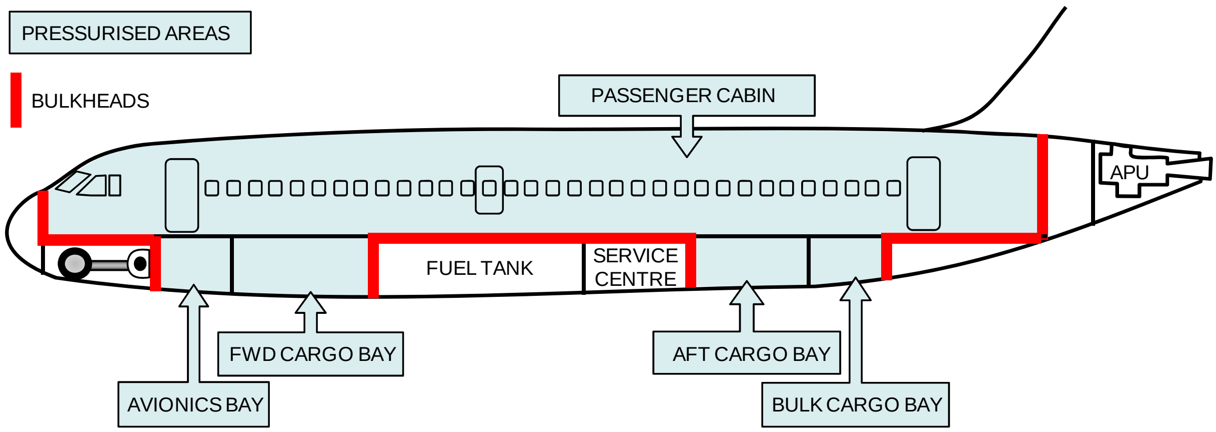


Figure 7-4 Pressurised Areas and Pressure Bulkheads

Any electrical wiring, flight control cables, control rods, hydraulic lines or other equipment that passes through a bulkhead must be provided with a leak proof entry or exit of the pressurised area. Control rods and cables must have freedom of movement through the bulkheads without imparting too much static friction. Refer to Figure 7-5. Other obvious leak points such as cabin doors, cargo doors, escape hatches and cockpit side windows that open are sealed with inflatable rubber seals.

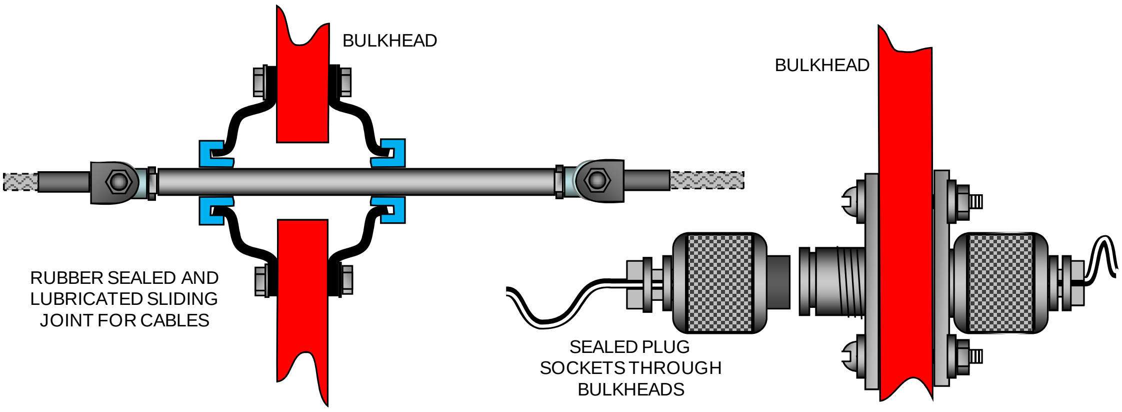


Figure 7-5 Equipment Sealing through Pressurised Bulkheads

PASSENGER EVACUATION AND OTHER EMERGENCY CONSIDERATIONS

Pressurised aircraft must incorporate specific features for the safety of passengers which include;

- ensuring that cabin doors can be opened for emergency evacuation at anytime the aircraft is on the ground,
- the ability to depressurise the aircraft quickly if required to clear smoke from the cabin, and
- the ability to ventilate the aircraft with ram air if normal pressurised airflow fails.

How these requirements are incorporated will be discussed later in this Chapter.

BRITISH CIVIL AIRWORTHINESS REGULATIONS (BCAR) REGARDING STRUCTURE

These Regulations lay down the laws relating to pressurisation in aircraft structures. Some of the major points are:

1. The aircraft designer will state the maximum pressure differential (p) and the maximum altitude (h) in the Flight Manual for the aircraft.
2. The value of “p” shall ensure a compartment pressure at the maximum height, “h”, at least equivalent to the height permitted by the Air Navigation Regulations without oxygen equipment.

Pressurised compartments shall be provided with at least the following:

a) Devices in duplicate which will, at the maximum rate of flow delivered by the compressors, automatically limit the positive differential to “p”. If in addition the aircraft is climbing at its maximum continuous rate of climb, the acceptable limit is extended to “p” ± 25 PSI. The capacity of each of these devices is such that if one should fail it would not cause an appreciable rise in pressure differential.

b) Devices in duplicate which will, with the cabin air supply compressors inoperative and with zero differential pressure at the start of a dive, automatically prevent the negative pressure differential, “p”(neg) from becoming high enough to damage the structure, when the aircraft loses height at its maximum practicable rate. <u>The negative differential pressure shall not normally exceed - 0.5 PSI</u>.

c) A manually operated device available to the flight crew by which the pressure differential can rapidly be reduced to zero.

d) A suitable automatic or manual regulator for controlling the internal pressure and rate of exchange of air.

REGARDING SUPPLY

Some of the requirements of the British Civil Airworthiness Requirements governing pressurised cabins are:

1. The air supply to the cabin shall be able to supply all differential pressures up to the maximum differential pressure and at all altitudes up to the maximum altitude.

2. The fresh air supply system shall be duplicated in all its essential functions. In the event of a failure of one part of the system the duplicated part of the system shall be able to supply <u>0.5 pound per minute per person</u>, where the total number of persons is taken to be the total number of seats as published in the flight manual for the aircraft. Normal air supply shall be <u>not less than one pound per person per minute</u>.

3. Fresh air ventilation shall be available on the ground and in flight at altitudes at which pressurisation is not required (below 10,000 feet).

4. The air supply shall be such that the entry of toxic gases into the cabin and crew compartment is prevented.

PRESSURISATION SUPPLY

Depending on aircraft type and as discussed earlier in Chapter 3, compressed air for pressurisation may be provided by numerous methods. A bleed air supply is the most common in large jet transport aircraft and this Chapter will focus on this method.

The common bleed air manifold provides the source via the air-conditioning system(s) for cabin pressurisation. The manifold is charged with compressed air from each main engine and the APU. This provides excellent redundancy as any single source can provide a sufficient amount of air to maintain cabin pressurisation.

Large duct non return valves are located within the system so that if an engine is shutdown or fails, pressurisation will not be lost back through the engine source. Refer to Figure 7-1.

Additionally, isolation valves are positioned within the system to isolate any duct leakage and ensure that at least some bleed air is always available for cabin pressurisation.

Note that the APU on most modern aircraft can be used as a source of bleed air in flight and is often used as the source for air-conditioning and initial pressurisation for take-off and climb.

Care must be taken when closing any control valves that form part of the aircraft pneumatic and air-conditioning systems to avoid disruption of the pressurisation supply. Refer to Figure 7-6.

WARNING

The pressurisation of the aircraft depends entirely on the availability of bleed air via the air-conditioning systems, therefore before selecting Engine Bleed Valves, Manifold Isolation Valves or Air-conditioning Units to OFF or CLOSED consider the impact to pressurisation supply.

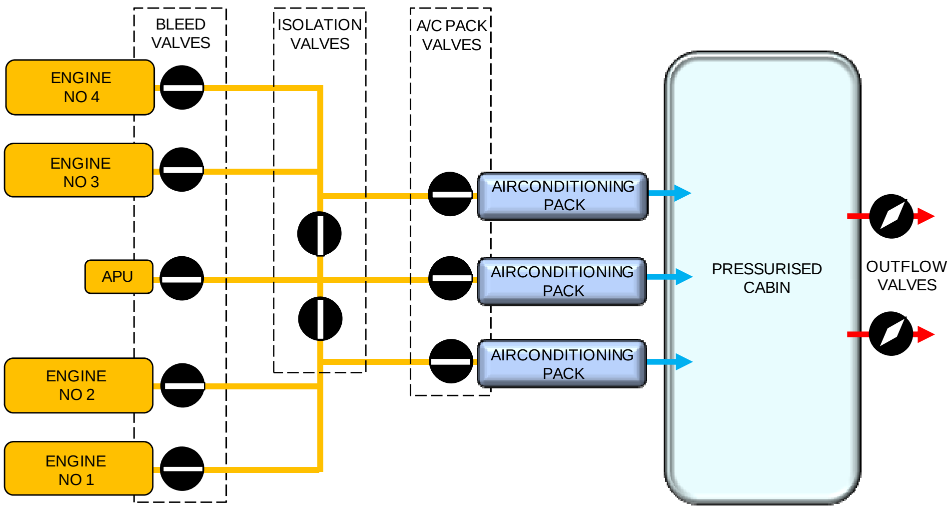


Figure 7-6 Pressurisation Supply

The bleed air supply for air-conditioning and pressurisation of the aircraft is subject to changes in pressure and flow rates due to such things as engine RPM, altitude, temperature and operation of other systems that use bleed air such as wing anti-ice. A stable mass flow is normally provided by the engine bleed valves which continuously modulate to suit the requirement for pressurisation. Modern Air-conditioning Pack valves will also perform the same function. Some smaller systems may use a mass flow controller which has been described in Chapter 4, Pneumatic Systems.

PRESSURISATION SYSTEM COMPONENTS

All of the components of a pressurisation system can be easily understood by dividing them into three groups; that is,

1. components that are used for normal pressurisation operation,
2. components that independently protect the aircraft structure, and
3. components used in emergencies to clear smoke and ventilate the aircraft.

GROUP ONE COMPONENTS

Normal pressurisation operation uses three basic components;

- Pressurisation Control Panel,
- Cabin Pressure Controller (CPC), and
- Cabin Outflow Valve(s).

PRESSURISATION CONTROL PANEL

In older pneumatically operated systems the Pressurisation Control Panel and the Cabin Pressure Controller are joined together as one item and it is of course located in the cockpit. Refer to Figure 7-7.

Electronically operated systems have a Control Panel in the cockpit which communicates with the Cabin Pressure Controller typically located in the avionic equipment bay.

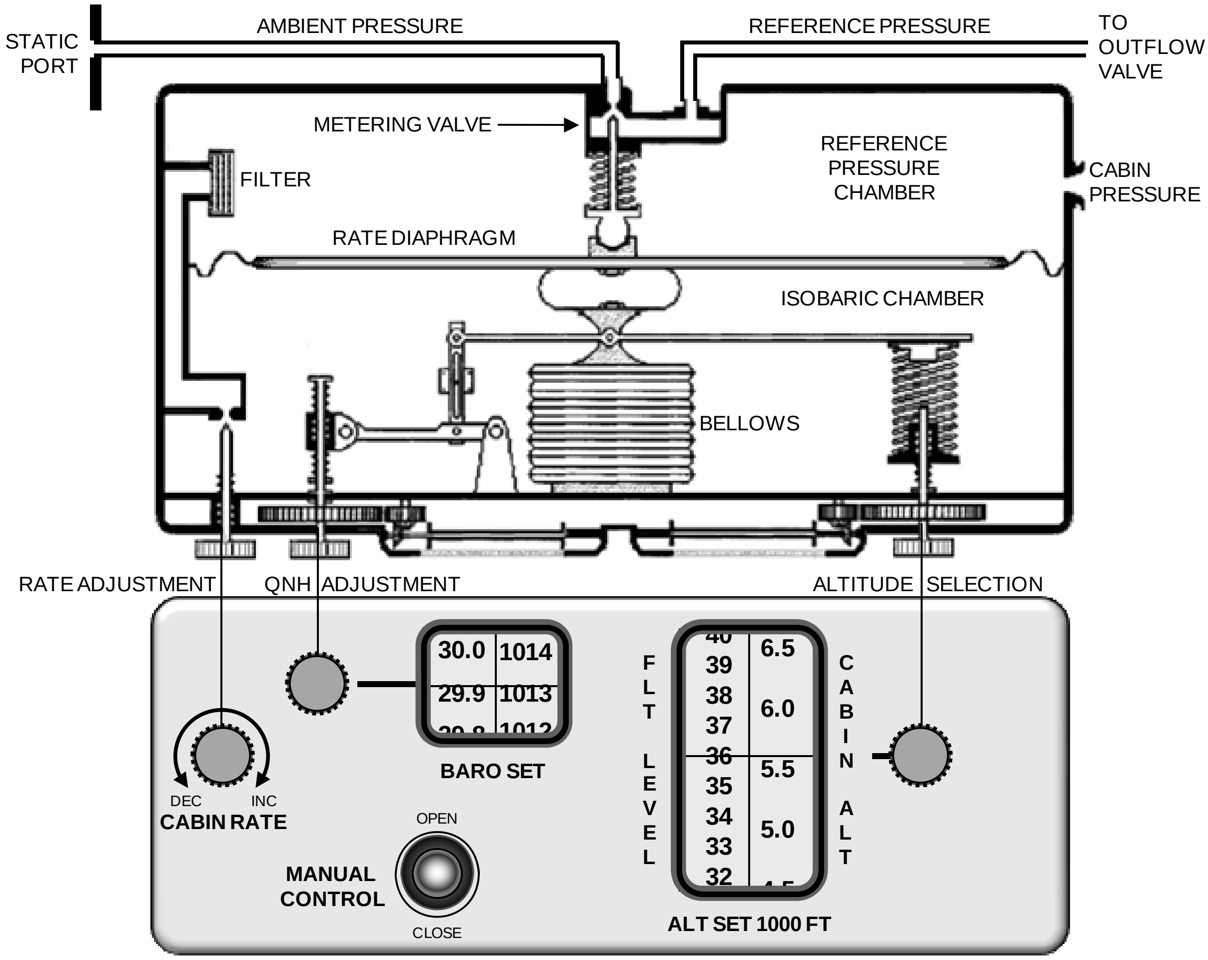
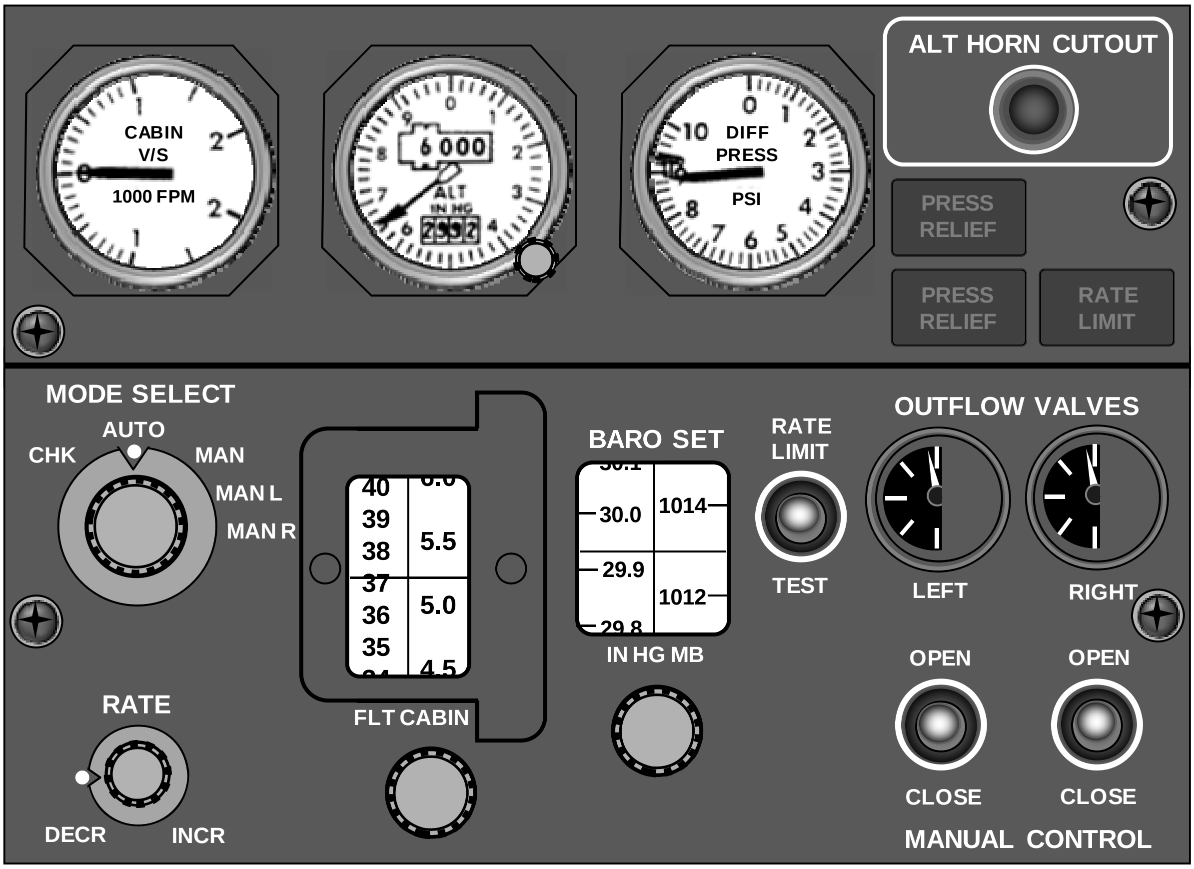
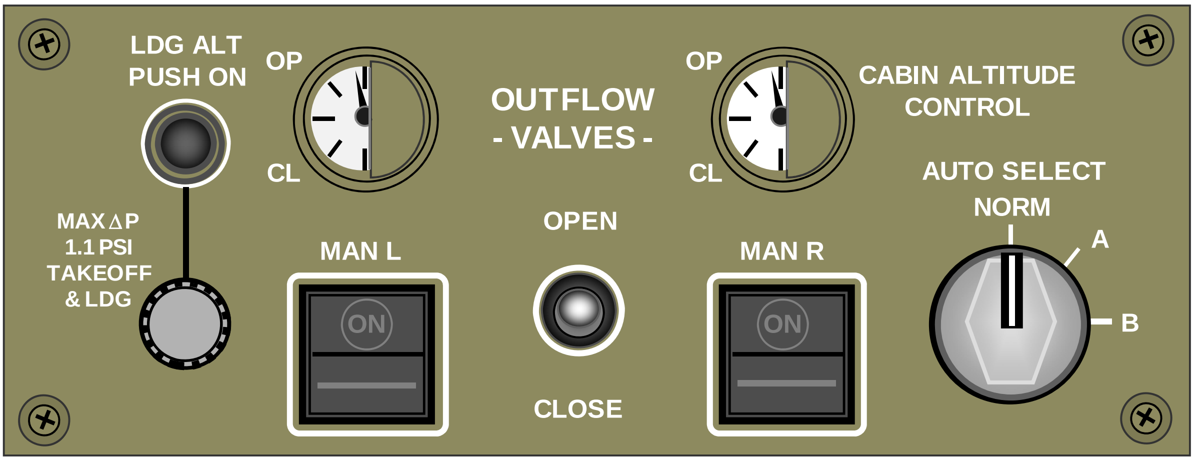


Figure 7-7 Control Panel and Controller as one Unit

A modern Pressurisation Control Panel is significantly different to the older types. This is due to the automation of the system and computer control. Note the difference between B747-Classic and B747-400 Control Panels. Refer to Figure 7-8.



B747 Classic



B747 - 400

Figure 7-8 Control Panels, B747 Classic and B747-400

CABIN PRESSURE CONTROLLER

The Cabin Pressure Controller is the device that controls the outflow valve(s).

Older style controllers used pneumatic pressure control for automatic (normal) operation and electrical control for manual (alternate) operation. Modern controllers use electrical control for both operations.

Pneumatic Cabin Pressure Controllers are set by the crew to the required cabin altitude and using a bellows, diaphragm and metering valve provide a pneumatic reference pressure to the outflow valve(s). The reference pressure which is a vacuum or negative pressure controls the position and rate of movement of the pneumatic outflow valve. Adjustments to cabin rate of change and local barometric pressure are also made by the crew. Refer to Figure 7-9.

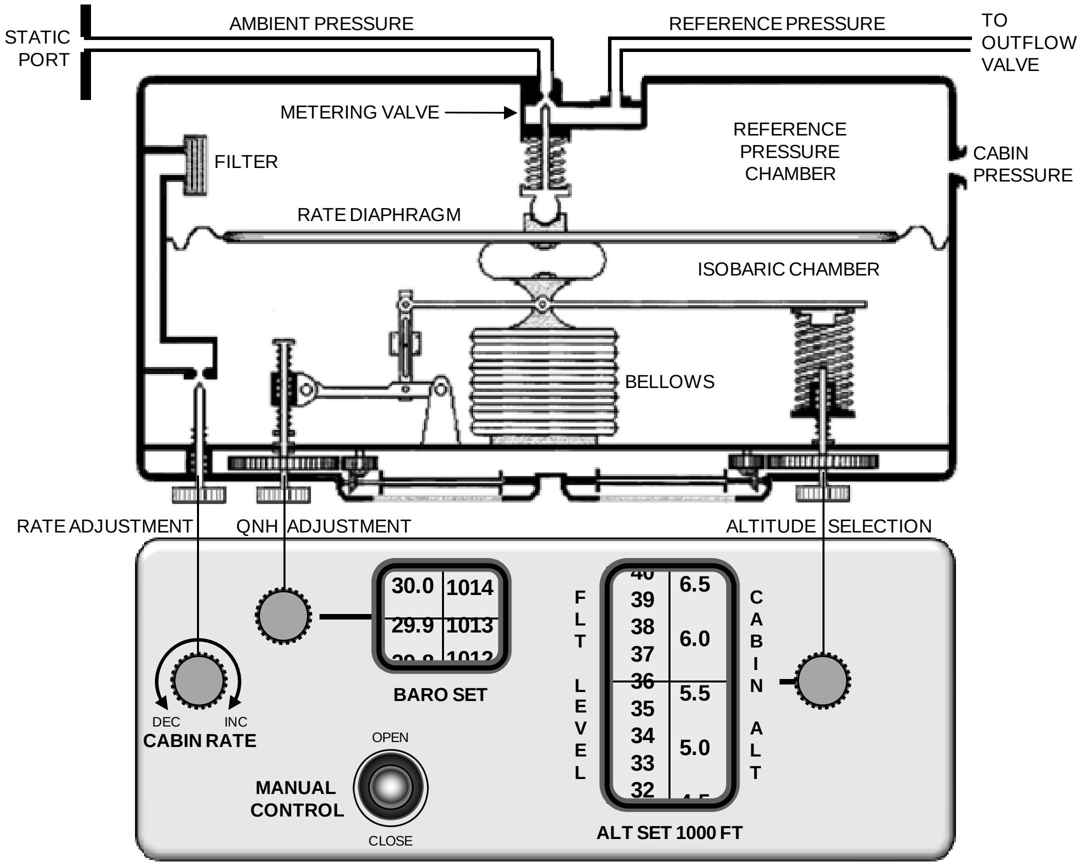


Figure 7-9 Pneumatic Cabin Pressure Controller

The operation of the pneumatic Controller and Outflow Valve(s) working together as a total system will be discussed later

Older Electronic Cabin Pressure Controllers are also set by the crew via the Pressurisation Control Panel to the required cabin altitude and using electronics only provide electrical signals to the outflow valve(s). Electric signals control the position and rate of movement of the electric outflow valve. Manual control of pressurisation is available at the Pressurisation Control Panel. Refer to Figure 7-8. B747-Classic Panel.

Modern Electronic Cabin Pressure Controllers are NOT set by the crew as all the information is available from the FMS, however, manual control of pressurisation is still available at the Control Panel. Refer to Figure 7-8. B747-400 Panel. The operation of the electronic Controllers and Outflow Valve(s) working together as a total system will be discussed later.

All types of Cabin Pressure Controllers have two ranges of normal or automatic operation. They are called;

- the Isobaric Range, and
- the Differential Range.

The ISOBARIC range is the NORMAL operating range where a pre-programmed schedule of cabin altitude is maintained to suit the aircraft altitude. The schedule of cabin altitudes versus aircraft altitudes provides adequate cabin pressure for passengers and reduces the differential pressure stress on the fuselage as much as possible. The cabin rate of change during climb or descent is programmed to be less than 500 fpm in climb and 300 fpm in descent. Refer to Figure 7-10.

The DIFFERENTIAL range is a safety feature of the cabin pressure controller to prevent over pressurising due to malfunction or mismanagement of the Pressurisation Control Panel. For example if the Cabin Pressure Controller malfunctioned in the normal Isobaric range and differential pressure began increasing, the Controller will default to the Differential range and maintain a fixed differential pressure of approximately 9.0 PSID. When operating in the differential mode any change in aircraft altitude will cause the cabin altitude to change at the same rate as the aircraft. Refer to Figure 7-10. In modern aircraft the differential range is referred to as the Differential Pressure Limiter.

<table>
<tr><th colspan="3">NORMAL OPERATION</th><td rowspan="13">DUE TO INCORRECT SETTING OR MALFUNCTION THE CPC WILL PROTECT THE AIRCRAFT BY DEFAULTING TO THE DIFFERENTIAL RANGE

THIS RANGE WILL NOT ALLOW DIFFERENTIAL PRESSURE TO INCREASE ABOVE 9.0 PSID</td><th colspan="3">SAFETY FEATURE</th></tr>
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<tr><td>MAXIMUM</td><td>8,000</td><td>8.9</td><td>MAXIMUM</td><td>7.800</td><td>9.0</td></tr>
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<tr><td colspan="7">THE VALUES SHOWN ABOVE ARE ONLY TO ILLUSTRATE THE PRINCIPLE. THEY DO NOT REPRESENT ACTUAL VALUES</td></tr>
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Figure 7-10 Isobaric and Differential Ranges

CABIN OUTFLOW VALVE(S)

The Cabin Outflow Valves control the rate of pressurised air exiting from the pressure hull to atmosphere. There must be two fitted for redundancy.

In automatic operation they simultaneously modulate to maintain the cabin altitude dictated by the Cabin Pressure Controller.

In manual operation they move simultaneously or individually as directed by the crew using manual switches on the Pressurisation Control Panel.

There are two basic types;

- Pneumatic Actuator (AUTO) with DC Electric Motor (MAN) back-up, and
- AC Electric Motor (AUTO) with DC Electric Motor (MAN) back-up.

For interest there are other types in use such as the B737-800 which uses only DC motors on a single outflow valve and this will be described briefly in the summary, Figure 7-24.

Pneumatic Actuator with DC Electric Motor back-up are the older type and are not used on modern aircraft. The reference pressure pipe has to connect to the cockpit, a long distance from the outflow valves and is subject to high maintenance for vacuum testing and leak fault finding.

When pneumatic control fails the outflow valve may be directly operated by the crew using a manual control toggle switch operating the DC electric motor. Refer to Figure 7-11.

The operation of the pneumatic Outflow Valve and pneumatic Controller working together as a total system will be discussed later.

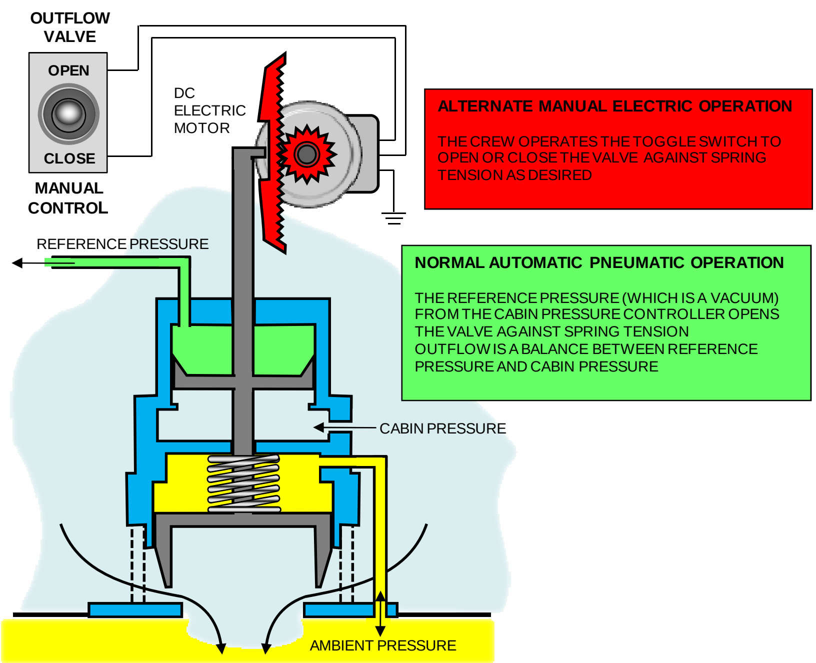

Figure 7-11 Pneumatic Outflow Valve

AC Electric motor with DC Electric motor back-up are the type used on modern aircraft. With the advent of the Air Data Computer as a source of all relative pressures needed, electrically operated outflow valves have become the common type.

A high speed AC motor continuously modulates under the direction of the Cabin Pressure Controller to maintain the cabin pressure accurately. For interest the high speed motor can operate the valve through full travel in 5 seconds.

When normal control fails or AC power is lost the outflow valve may be directly operated by the crew using a manual control toggle switch. For interest the low speed DC motor operates the valve through full travel in 25 seconds. Refer to Figure 7-12.

The operation of the Electric Outflow Valve and the Electronic Controller working together as a total system will be discussed later.

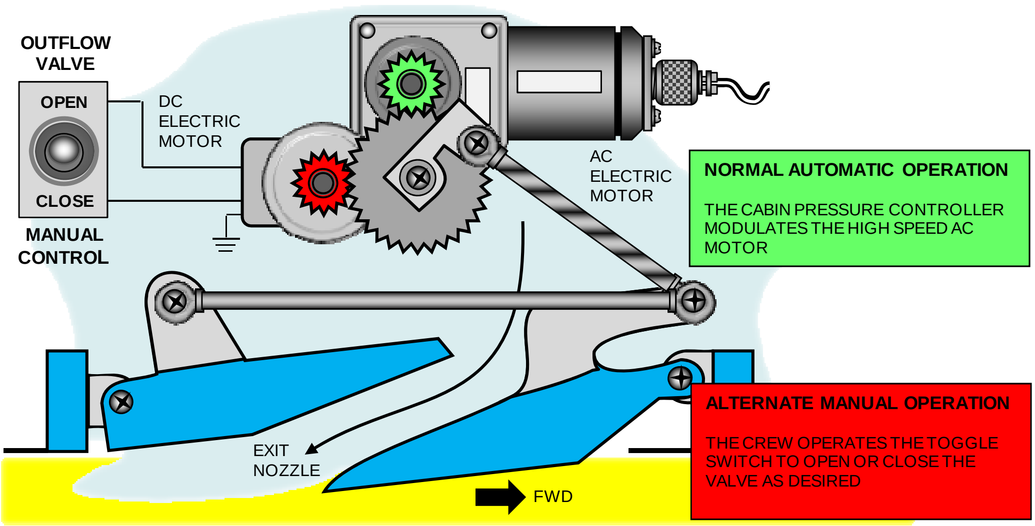

Figure 7-12 Electric Outflow Valve

Outflow valves are always located on the underside of the fuselage and depending on aircraft type are typically located as shown in Figure 7-13. The valves normally operate in parallel. Cabin altitude and full ventilation rates can be maintained by either valve.

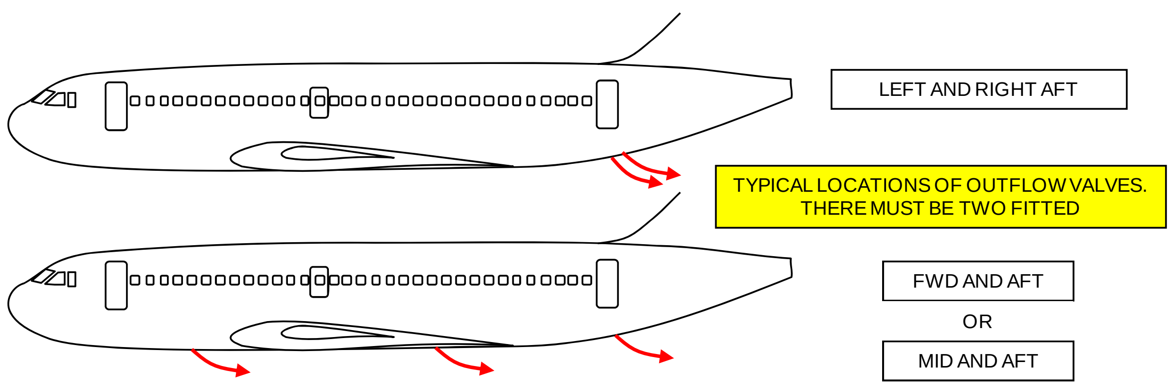

Figure 7-13 Outflow Valve Locations

GROUP TWO COMPONENTS

The components in this group are fitted to protect the pressure hull from structural failure. These components are totally independent of the first group. They are;

- Safety Valves (positive pressure relief),
- Negative Pressure Relief valves, and
- Blowout Panels.

POSITIVE PRESSURE RELIEF OR SAFETY VALVES

The purpose of the positive pressure relief or safety valves is to prevent an overpressure occurring inside the pressurised hull beyond the safe structural limit.

This can occur if the aircraft's pressurisation system integral differential protection fails to limit overpressure. Safety valves are totally independent of the aircraft's pressurisation system and are normally set to operate at a slightly lower pressure than the aircraft's published maximum pressure differential. There should be two fitted to the aircraft for redundancy.

Safety valves will indicate in the cockpit when they are open by an amber annunciator light or alert message. Refer to Figure 7-14.

Some types are fitted with a telltale streamer that remains visible on the outside of the aircraft after the valve has closed thus indicating to maintenance staff that the valve had operated during the flight. A safety valve should never have to open if the aircraft's pressurisation system is functioning correctly.

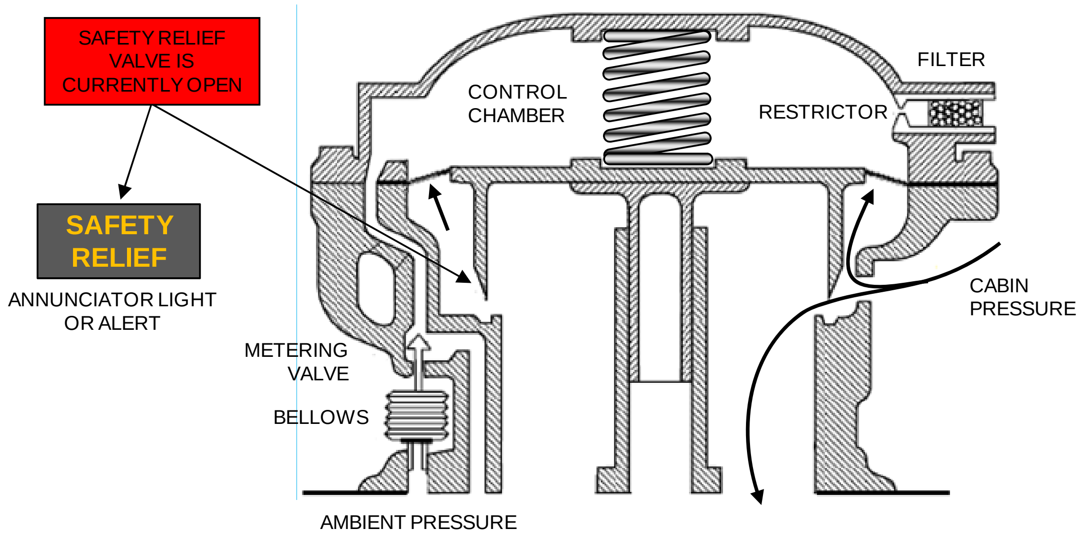

Figure 7-14 Safety Relief Valve (positive pressure)

The control chamber is subjected to cabin pressure through a restrictor and this, along with the spring, keeps the safety valve closed. Ambient pressure is sensed by a bellows which controls a metering valve connecting the control chamber with atmosphere.

The outside of the bellows is subject to cabin pressure and when the maximum differential pressure is reached the bellows collapses and the metering valve opens allowing control chamber pressure to escape. The cabin pressure acting on the lower chamber opens the safety valve.

As cabin pressure decreases and differential pressure falls back below the maximum limit the bellows expands, closing the metering valve and allowing control pressure to build up and close the safety valve.

NEGATIVE PRESSURE RELIEF VALVES

The purpose of the negative pressure relief valves is to equalise differential pressure when the outside pressure is higher than the cabin pressure.

This will prevent in the worst case the hull being crushed by outside pressure but also ensures that outward opening doors such as cargo doors and some emergency exits can be opened easily. Negative pressure relief valves are totally independent of the aircraft's pressurisation system. There should be at least two fitted to the aircraft for redundancy.

These are simple spring loaded valves that are typically of a rectangular shape located mostly on all cargo doors. There must be at least two fitted to the aircraft and they must open when differential pressure exceeds 0.5 PSID. Once differential pressure is relieved they will close automatically. Refer to Figure 7-15.

For interest, on Boeing aircraft they are also mechanically connected to the cargo door opening handle so that when the cargo doors are unlocked any residual differential pressure is relieved.

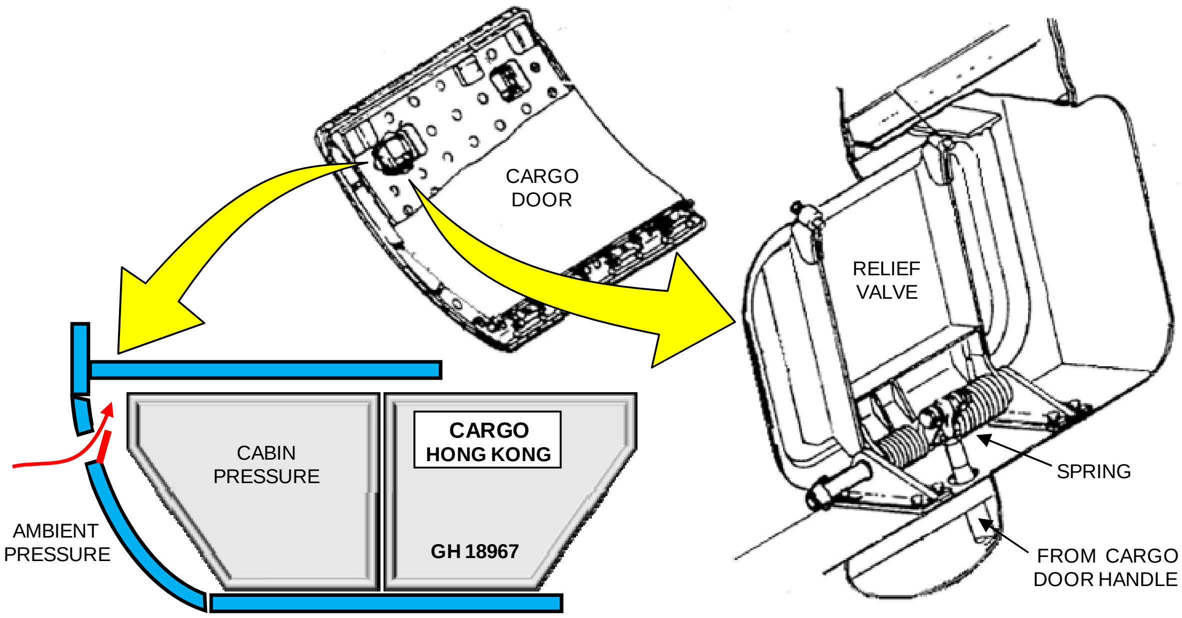

Figure 7-15 Negative Relief Valve (negative pressure)

Generally speaking the Safety Relief Valves (positive pressure) are located on the LH side of an aircraft and the Negative Pressure Relief Valves on the cargo doors on the RH side.

Refer to Figure 7-16. For interest Airbus aircraft use a combination positive and negative relief valve located at the tail of the aircraft.

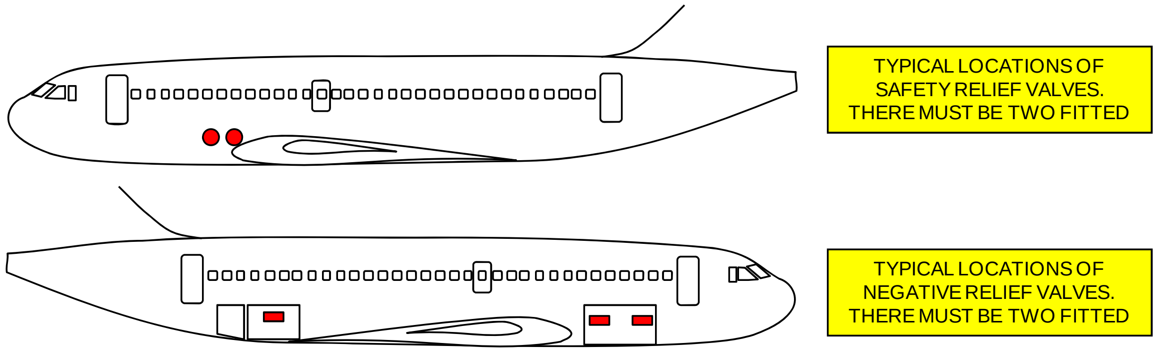

Figure 7-16 Positive and Negative Relief Valve Locations

BLOWOUT PANELS

Blowout panels are fitted between passenger and cargo compartments in order to prevent rapid excessive differences in pressure occurring between these areas in the event of, for example, a cargo door opening in flight.

Blowout panels may also be fitted to unpressurised external sections of the aircraft so that if the pressure hull ruptures the resultant large volume of compressed air can be vented overboard without destroying critical structures such as the empennage.

GROUP THREE COMPONENTS

These components are provided for clearing smoke or fumes from the cockpit or cabin. Some of these perform other normal functions but can be switched by the crew to remove smoke. Others are specifically designed for smoke removal or ventilation. The operation of any of these will have an effect on the pressurisation of the aircraft. They are;

- Smoke Evacuation Ports,
- Extract Overboard or Dump Valves, and
- Ram Air Valves.

SMOKE EVACUATION PORTS

Older aircraft and some modern aircraft such as the B747-400 are fitted with a smoke evacuation port or opening located at the top of the cockpit which may be opened whilst the aircraft is pressurised. This small opening is mechanically connected to a pull open handle. The port can be closed when smoke has cleared with no significant loss of pressurisation. Refer to Figure 7-17.

EXTRACT OVERBOARD OR DUMP VALVES

An important component of the avionics cooling system is a large valve located at the lower section of the forward fuselage.

This valve normally controls airflow from the avionics bay automatically but may be overridden for emergencies such as smoke extraction or ditching. There are numerous names for this valve depending on the aircraft type.

On very old aircraft with no avionics to cool, this valve was known simply as a pressurisation dump valve or in some older aircraft fitted with pneumatic outflow valves a dump function was incorporated so that the outflow valves could act as dump valves.

Modern aircraft typically have **TWO** valves, one for **DUMPING ONLY** and one for **COOLING and DUMPING**. Refer to Figure 7-17 and Figure 7-18. The operation of the flow control valve will be discussed in Chapter 6, Air-conditioning Systems.

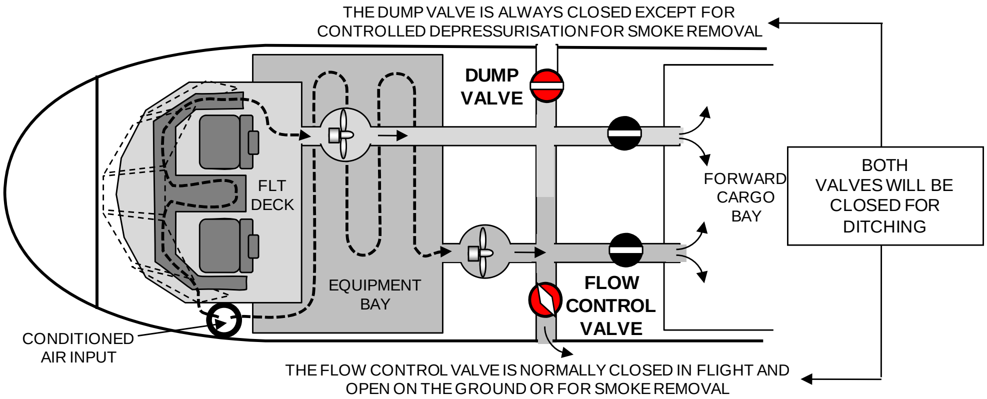

Figure 7-17 Dump Valve and Equipment Cooling Flow Control Valve

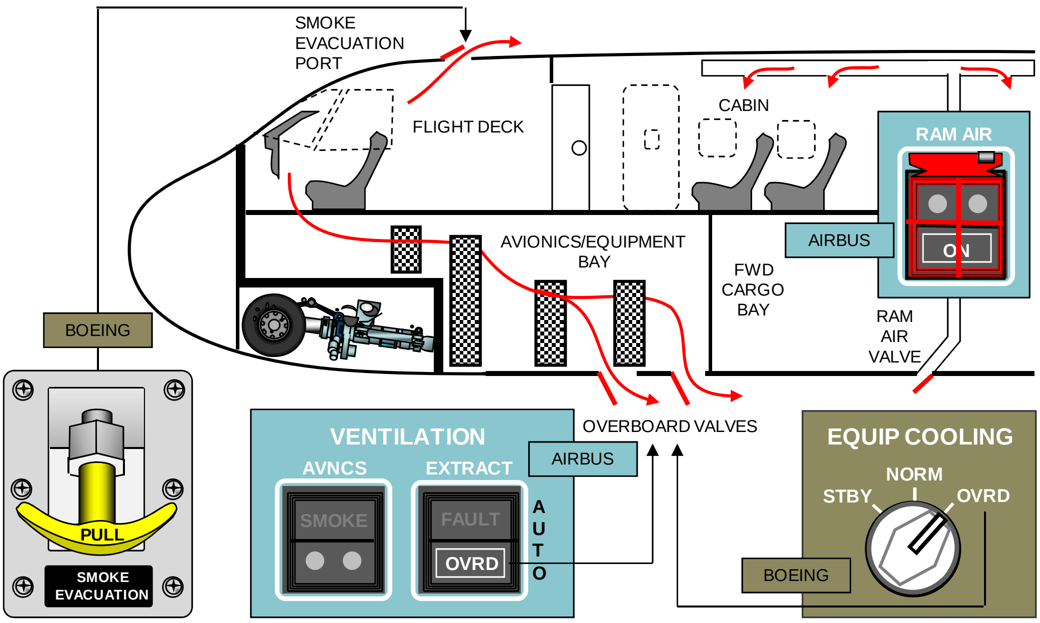

Figure 7-18 Valves to clear Smoke and Ventilate

RAM AIR VALVES

If an aircraft is being depressurised to clear smoke and the air-conditioning units are turned off, the aircraft must be ventilated. This is achieved by opening a valve allowing ram air to enter the cabin via the air-conditioning distribution ducting or cockpit. Refer to Figure 7-18.

The operation of this valve will be discussed in Chapter 5, Air-conditioning Systems.

SUMMARY

The following table is a summary of the components that relate to an aircraft's pressurisation system. Refer to Figure 7-19.

COMPONENT GROUP FOR	COMPONENTS	METHOD OF OPERATION	COMMENT
NORMAL OPERATION	PRESSURISATION CONTROL PANEL CABIN PRESSURE CONTROLLER OUTFLOW VALVES x 2	AUTOMATIC AND/OR CREW ACTIVATED	Modern operation is dual computer controlled
PRESSURE HULL PROTECTION	SAFETY RELIEF VALVES x 2 NEGATIVE RELIEF VALVES x 2 BLOWOUT PANELS	AUTOMATIC	Totally independent of any other systems
EMERGENCY SMOKE REMOVAL AND VENTILATION	SMOKE EVACUATION PORT DUMP VALVES EXTRACTION VALVE RAM AIR VALVE	CREW ACTIVATED	Only used for specific emergencies

Figure 7-19 Summary of Components

PRESSURISATION OPERATION

CABIN PRESSURISATION PROFILE

During a typical flight the pressurisation system will mimic the aircraft's altitude change profile with the appropriate cabin altitude profile as shown in Figure 7-20. The cabin altitude achieved is based on the ISOBARIC schedule for each aircraft cruise altitude. The Cabin Pressure Controller must be reset to the next new cruise altitude just prior to each altitude change.

In older aircraft the crew must reset the Cabin Pressure Controller whereas in modern aircraft the Controller is reset automatically by the FMS based on the entered flight plan.

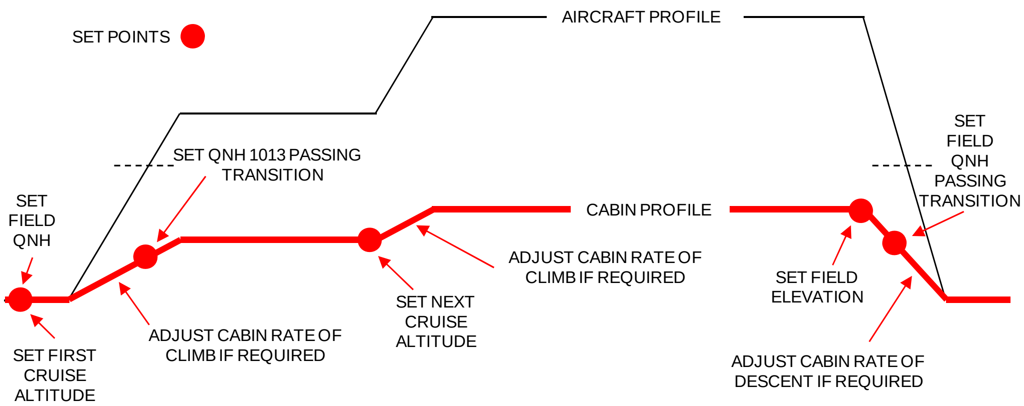

Figure 7-20 Cabin Pressurisation Profile

NORMAL PROCEDURES

The normal pressurisation procedures carried out by the crew differ considerably between classic and modern aircraft.

In older aircraft the Pressurisation Control Panel is SET by the crew prior to take-off, at each flight level change and prior to descent. Adjustments to Cabin Rate of Change and QNH are also made by the crew. Refer to Figure 7-21.

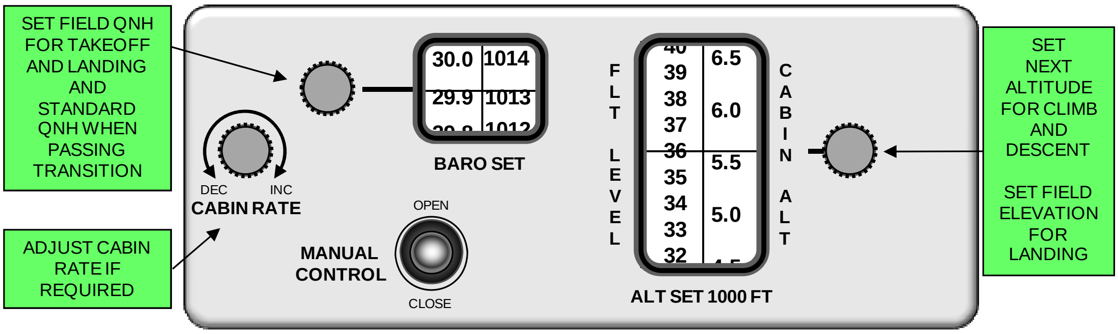

Figure 7-21 Crew Setting of Pressurisation Profile

In modern aircraft the Pressurisation Control Panel is NOT touched by the crew unless a malfunction of the automatic system occurs. Information required by the pressurisation system has been entered into the FMS with the flight plan and QNH adjustments are made automatically when the Pilot's Altimeters (QNH) are changed.

Adjustment of the landing altitude is the only option available to the crew in normal operation and this is only used in special circumstances such as landing at field elevations greater than 8,000 ft PA and some types of malfunctions.

Modern systems use two Cabin Pressure Controllers which are now computers, A and B or 1 and 2 to control pressurisation. Each computer alternates as the primary controller after each touchdown, the other acting as automatic backup. Crew may select a specific computer if required. Refer to Figure 7-22.

In both types manual pressurisation control is available via switches on the Control Panel.

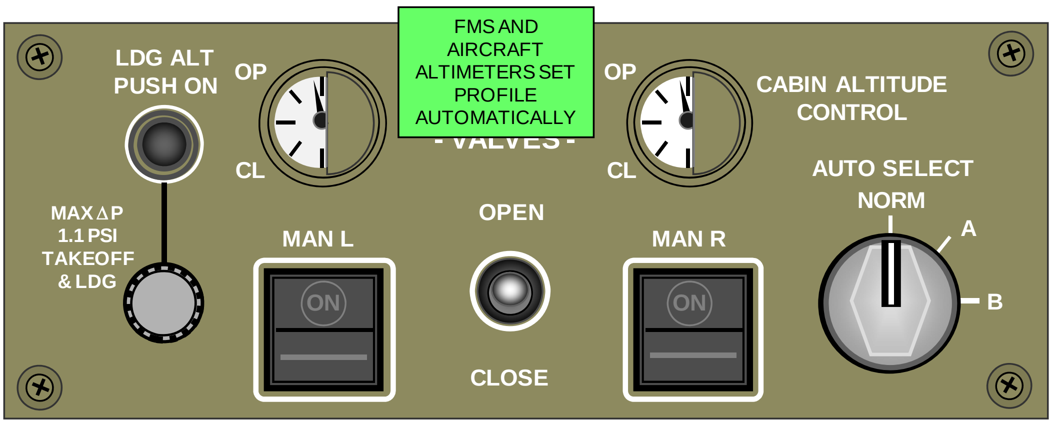

Figure 7-22 Computer Setting of Pressurisation Profile

SYSTEM OPERATION WITH A PNEUMATIC CONTROLLER

The crew presets the next aircraft cruise altitude which sets the bellows and diaphragm to a datum position representing the scheduled cabin altitude. The expected cabin altitude is displayed when the aircraft cruise altitude is set.

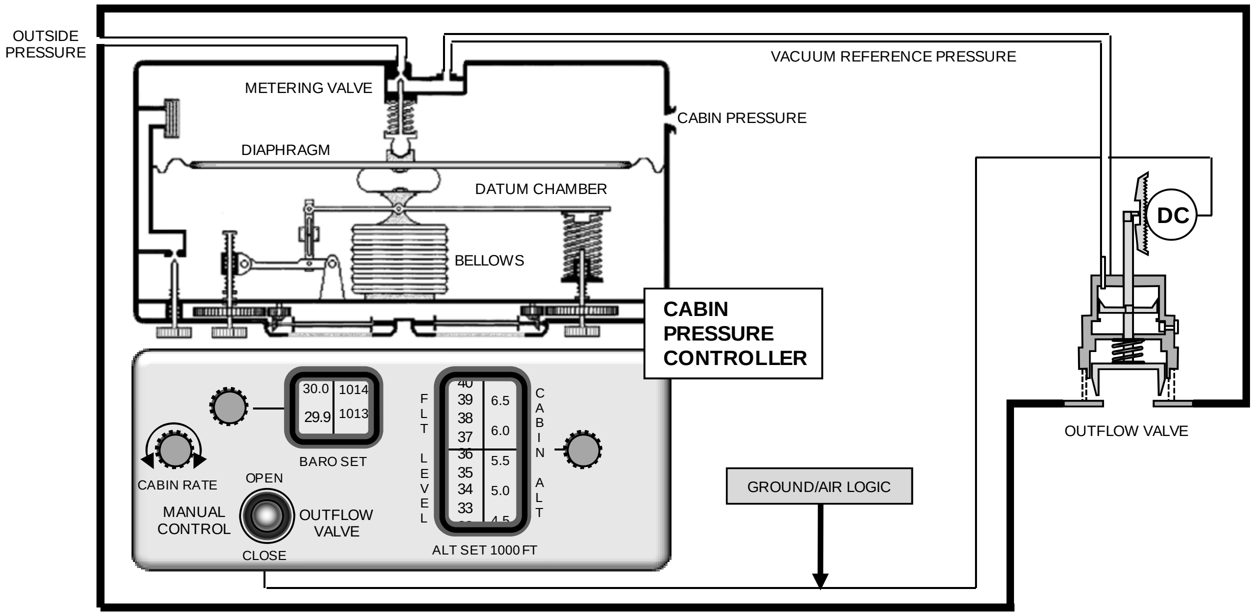

Figure 7-23 System Operation with a Pneumatic Controller

The outflow valve is held fully open on the ground (electrically) to allow for emergency evacuation and after take-off will switch to pneumatic operation. After take-off the outflow valve will close under spring tension and begin pressurising the aircraft.

As the aircraft climbs and outside air pressure decreases a vacuum pressure will form and open the outflow valve to increase the cabin altitude proportionally.

The operation of the diaphragm and metering valve provides a reference vacuum pressure for the outflow valve to use in controlling the valve against spring tension.

If the normal pneumatic system fails the outflow valve may be operated electrically by the crew using a small DC motor normally powered from a DC essential/vital power supply.

This is known as MANUAL pressurisation and it requires constant manipulation by the crew to maintain a stable cabin altitude. Refer to Figure 7-23.

SYSTEM OPERATION WITH AN ELECTRONIC CONTROLLER

The crew presets the next aircraft cruise altitude which instructs the Cabin Pressure Controller. The expected cabin altitude is displayed when the aircraft cruise altitude is set. The controller maintains cabin pressure based on the programmed schedule.

With the Rate Control set at the détente position a 150 FPM rate of climb or descent will be scheduled.

The outflow valve is held fully open on the ground with a false high cabin altitude to allow for emergency evacuation and after take-off will switch to true operation.

As the aircraft climbs the outflow valve will close under direction from the cabin pressure controller and begin pressurising the aircraft.

If the normal electronic system fails the outflow valves may be operated electrically by the crew using small DC motors normally powered from a DC essential/vital power supply. This is known as MANUAL pressurisation and it requires constant manipulation by the crew to maintain a stable cabin altitude.

This MANUAL system has a number of options in that if only one AC motor failed it can be switched to manual and automatic control could remain in operation using the serviceable outflow valve. Refer to Figure 7-24.

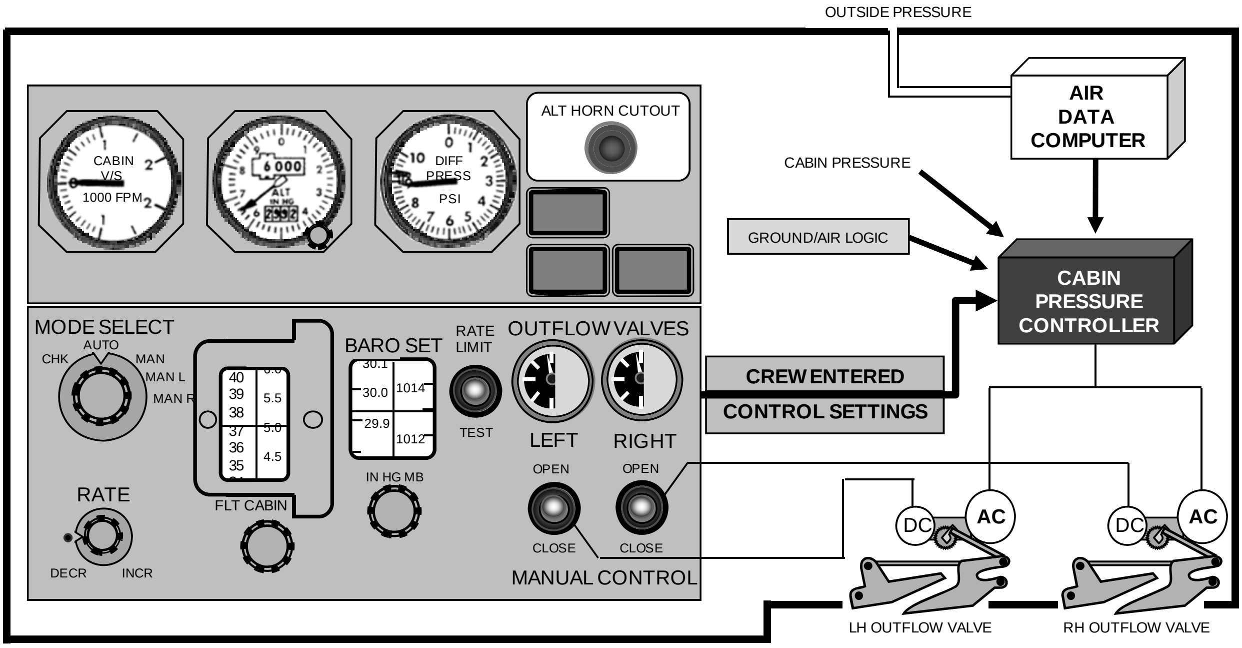

Figure 7-24 System Operation with an Electronic Controller

SYSTEM OPERATION IN MODERN AIRCRAFT

The crew enters the flight plan details into the FMS. This information is available to the Cabin Pressure Controllers (computers) when triggered to use it. Other inputs are provided by the air data computer, ground/air logic, thrust setting, cabin doors and pilot's altimeters.

Each computer alternates as the primary controller after each touchdown, the other acting as automatic backup. Under normal circumstances the crew is NOT required to touch any controls on the Pressurisation Panel.

The controllers operate in modes, for example; take-off, climb, cruise, descent and landing. The aircraft must begin the phase of flight before the controller changes to the related operating mode. For example, the aircraft must begin a descent before descent mode activates.

For interest each mode has specific features to suit the situation, some examples are;

- The computer begins to pressurise the aircraft on the take-off roll to reduce passenger discomfort and again at landing slowly depressurises 80 secs after touchdown.
- The computer retains the take-off field elevation and QNH until the aircraft has definitely started to climb in case an emergency return to land is conducted.
- In cruise mode if flights are short, less than 2.5 hrs, maximum cabin altitude is 8,000 ft. For long sectors more than 2.5 hrs the cabin altitude is decreased to 7350 ft to reduce passenger tiredness.
- In take-off mode with any cabin door unlocked the computer will not begin pressurising.

Adjustment of the landing altitude is the only option available to the crew in normal operation and this is only used in special circumstances such as landing at field elevations greater than 8,000 ft PA and some types of malfunctions.

If both computers fail the outflow valves may be operated electrically by the crew using small DC motors normally powered from a DC essential/vital power supply. This is known as MANUAL pressurisation and it requires constant manipulation by the crew to maintain a stable cabin altitude. Figure 7-25.

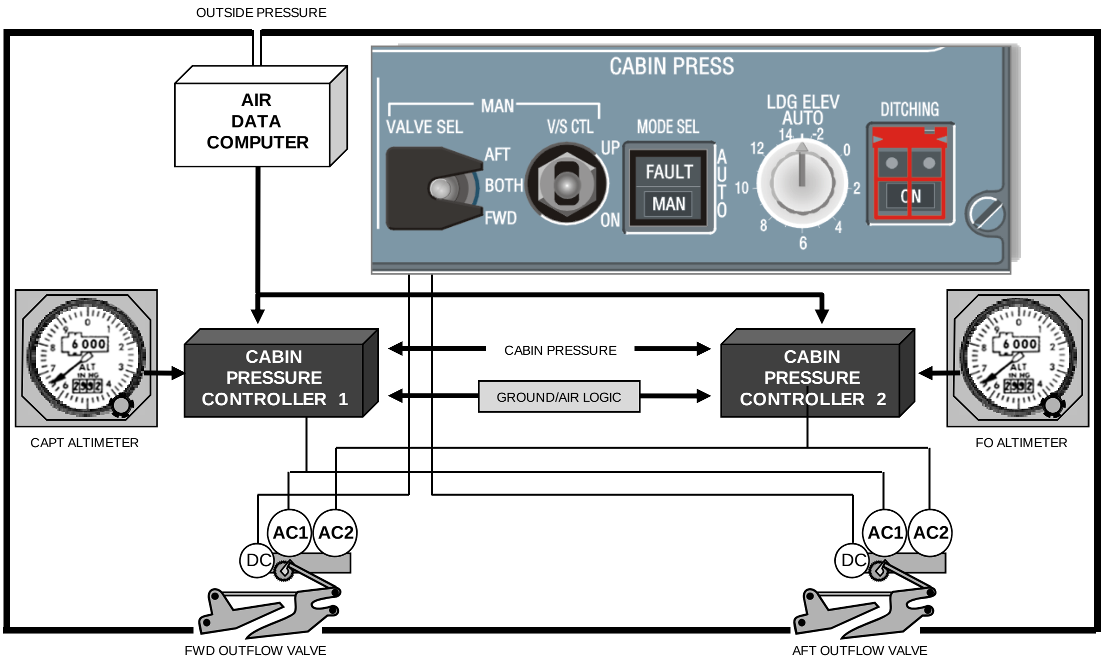

Figure 7-25 System Operation in Modern Aircraft

SUMMARY

Types of pressurisation systems depend mainly on the size of the aircraft and when it was designed and built. Refer to Figure 7-26 for a summary.

AIRCRAFT AGE	SYSTEM TYPES	CREW CONTROL	ASSOCIATION OF INPUTS	TYPICAL AIRCRAFT
OLDER	Pneumatic one controller single outflow valve	Enter cruise altitude Enter land altitude Adjust Rate	Ground/Air logic	L188 Electra
SEMI MODERN LARGE	Electronic one controller dual outflow valves	Enter cruise altitude Enter land altitude Adjust Rate	Ground/Air logic Air Data computers	B747-Classic
SEMI MODERN SMALL	Electronic one controller single outflow valve	Ground/Flight switch Enter cruise altitude Enter land altitude	Ground/Air logic Air Data computers	B737-200 The Ground/Flight switch is used to start pressurisation on the ground before take-off and to depressurize after landing
MODERN LARGE	Computer controlled two controllers dual outflow valves	Don't touch unless a malfunction occurs	Ground/Air logic Air Data computers Engine thrust Cabin doors locked	A330, 340, 380 B747-400, B777
MODERN SMALL	Computer controlled two controllers single outflow valve	Don't touch unless a malfunction occurs	Ground/Air logic Air Data computers Engine thrust Cabin doors locked	A320
	Computer controlled two controllers single outflow valve with 3 DC motors	Enter cruise altitude Enter land altitude	Ground/Air logic Air Data computers Engine thrust	B737-800

Figure 7-26 Summary of Pressurisation Systems

PRESSURISATION SYSTEM INDICATIONS AND WARNINGS

Pressurisation System Indications

All aircraft have a Pressurisation Control Panel in the cockpit. On older generation aircraft it will contain the indicators mentioned below along with controls to set or program the system. In older aircraft it is up to the crew to regularly monitor the analog indications to detect a discrete malfunction. Some systems do provide an annunciator light to warn of excessive cabin rate of change. Refer to Figures 7-8 “B747-Classic Panel” and 7-26.

Normal System Indications

The cockpit indications of a functioning pressurisation system are three gauges and two valve position indicators. They are;

- Cabin Altitude,
- Cabin Vertical Speed,
- Differential Pressure, and
- Outflow Valve Position Indicators.

Some systems add annunciator lights to warn of excessive cabin rate of change. Refer to Figure 7-27.

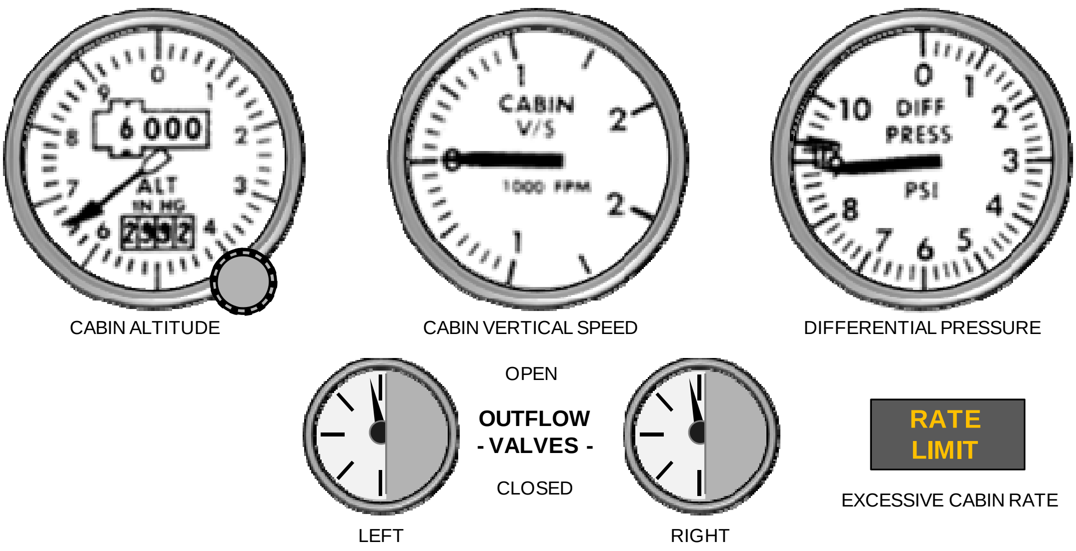

Figure 7-27 Pressurisation System - Analog Presentation

Modern large aircraft fitted with an ECAM or EICAS will display the above indications in digital format leaving only the switches required for abnormal operation on the Pressurisation Control Panel. Additionally the ECAM/EICAS synoptics will display real time status of the components.

In modern aircraft small malfunctions will be detected by the computers and displayed on ECAM or EICAS. This will be accompanied by "alerts" to the crew. A typical modern pressurisation system is monitored for the following parameters;

- the current cabin pressure, cabin rate of change and differential pressure,
- the position of the outflow valves,
- the current landing altitude set by the FMS,
- the current computer in control and mode of operation,
- excessive cabin rate of change, and
- the position of other relevant valves associated with aircraft pressurisation.

Status of Controls and Systems

In modern large aircraft the pressurisation system(s) are continuously monitored by computers. The software is programmed to make the operator aware not only of malfunctions but also to provide the current position of controls and mode status. Synoptic presentations make greater use of colour to indicate the status of components and the system. Colours follow the same pattern as previously described in other Chapters. Refer to Figure 7-28.

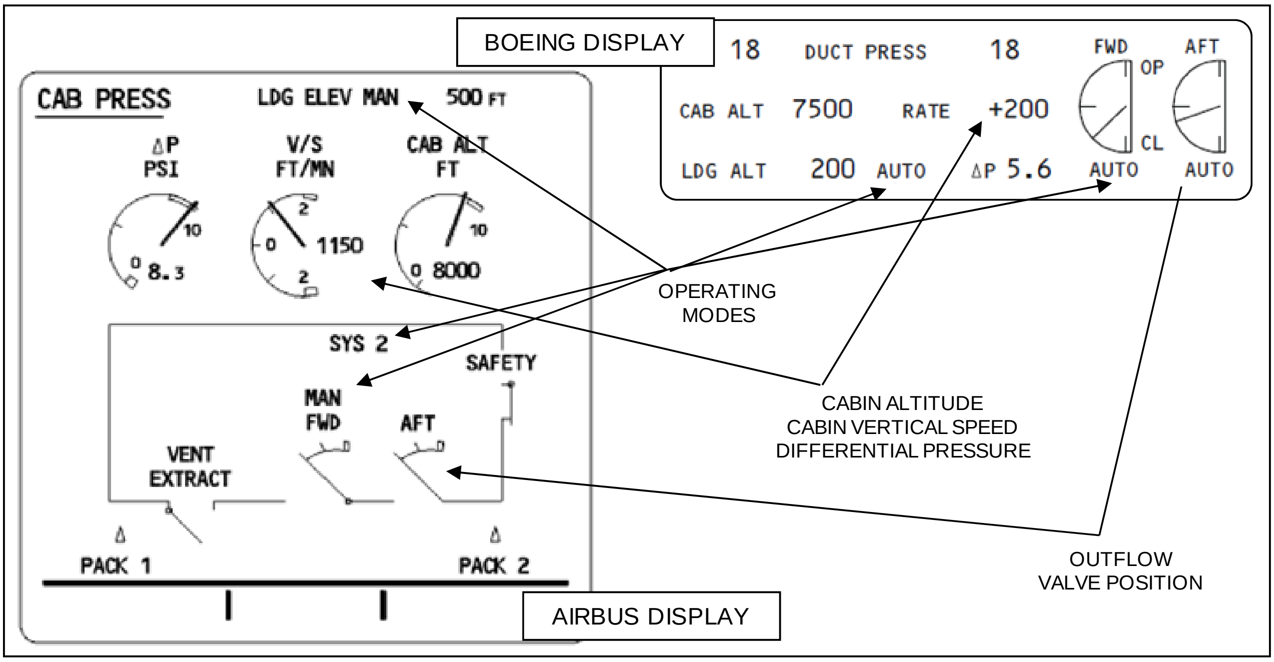

Figure 7-28 Pressurisation System – ECAM and EICAS Presentations

ABNORMAL SYSTEM INDICATIONS AND FAILURE

The abnormal or failure cockpit indications are provided by either individual annunciator lights or ECAM/EICAS caution advisories. They will be an AMBER caution light or advisory and will require the crew to take some action immediately. There will be a checklist to follow for these problems.

***Excessive Rate of Change* (caution) –** if an abnormally high rate of cabin change is detected outflow valves will respond automatically to decrease the rate of change and alert the crew.

***Controller Fault* (caution) –** if a Cabin Pressure Controller fails the other will take over automatically and alert the crew.

***Safety valve(s) Open* (caution) –** if a safety valve opens the crew is alerted/

***Excessive Cabin Altitude* (warning) –** if the cabin altitude reaches 10,000 ft at any time. This is a RED light with AURAL warning on most aircraft.

In older aircraft, a separate system called the Cabin Altitude Warning System will alert the crew. This system is discussed on Page 26.

In modern aircraft the same excessive cabin altitude warning is integrated into the pressurisation system computers and they will not only provide the same warning to the crew (red alert) but also automatically begin closing the outflow valves to restrict pressurisation loss.

TYPICAL MALFUNCTION ALERTS IN PRESSURISATION SYSTEMS

The following table details some examples of the malfunction alerts and possible faults that are presented to the crew in switches and on ECAM/EICAS in modern pressurisation systems found today. Refer to Figure 7-29.

ALERT MESSAGE	ALERT LEVEL	AURAL	FAULT
CABIN ALTITUDE	WARNING	SIREN	Cabin altitude is excessive, above 10,000 FT.
CABIN ALT AUTO	CAUTION	BEEPER	Both Cabin Pressure Controllers failed or both Outflow Valves MANUAL switches ON.
OUTFLOW VALVE L, R	ADVISORY		Auto control of Outflow Valve is inoperative, or, respective Outflow valve MANUAL Switch is ON.
LANDING ALT	ADVISORY		Disagreement between controller landing altitude and FMC landing altitude, or, landing altitude in MAN.
PRESS RELIEF	ADVISORY		Either Safety Relief Valve opens.
FAULT LIGHT (in switches)	ADVISORY		Check ECAM for further information about the fault.

Figure 7-29 Malfunction Alerts in Pressurisation Systems

THE CABIN ALTITUDE WARNING SYSTEM

INTRODUCTION

Already mentioned at the beginning of this chapter is the fact that the human body requires a continuous supply of oxygen to be forced into the bloodstream by atmospheric pressure. Above 10,000 ft the atmospheric pressure is such that the initial symptoms of hypoxia may begin to occur. The first symptom is tiredness which may lead to the crew not realising that the atmospheric pressure in the aircraft is too low. If cabin altitude continues to increase eventually the crew will become unconscious leading to a disastrous result.

THE SYSTEM

<u>The system has two trigger altitudes at which time automatic action will take place.</u>

At 10,000 Cabin Altitude a Cabin Altitude warning light will illuminate and a horn or other audible alert will sound indicating that the cabin has reached the maximum safe altitude for flight without supplementary oxygen being provided for passengers. The horn may be cancelled by a horn silence button, but the only way to extinguish the light is to descend the cabin to below 10,000 feet. It is very important that the cabin altitude be reduced to make the warning light go out. This allows the warning system to indicate any further increase in cabin altitude which otherwise may not be noticed.

At 14,000 Cabin Altitude another warning will be initiated. This will consist of the Cabin Altitude Light and horn as before, whilst in the cabin the supplementary oxygen masks will fall, the "Fasten Seat Belts" signs will illuminate and a pre-recorded message will play on the public address system. None of these warnings are able to be cancelled, except by descending the aircraft to below 10,000 feet cabin altitude. Refer to Figure 7-30.

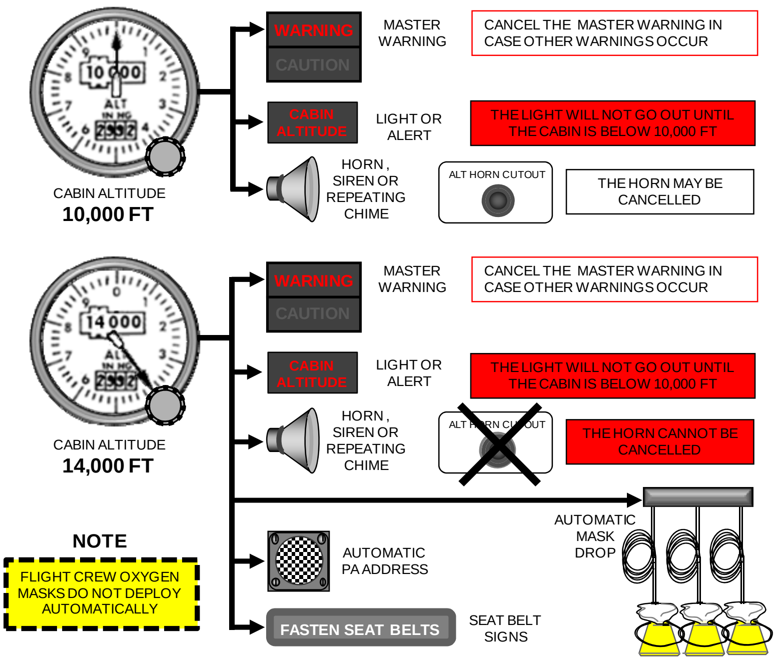

Figure 7-30 Cabin Altitude Alerts and Automatic Operation

PRESSURISATION SYSTEM REDUNDANCY AND ALTERNATE OPERATIONS

ALTERNATE AND EMERGENCY OPERATION

The term alternate operation refers to a mechanism or another system that is the alternate to the normal method of operation. Some aircraft have both an alternate method and an emergency method for systems. In some aircraft, the alternate method is referred to as emergency operation. The aircraft's pressurisation system alternatives are listed in the following table.

Refer to Figure 7-31.

NORMAL OPERATION	FIRST ALTERNATE	SECOND ALTERNATE	EMERGENCY
CPC controls both outflow valves (dual CPC system)	Other CPC/computer takes over and controls both outflow valves	Crew takes control of both outflow valves manually	Descend the aircraft to 10,000 ft
CPC controls both outflow valves (single CPC system)	Crew operates one outflow valve to a manual fixed position then allows the CPC to control the other outflow valve	Crew takes control of both outflow valves manually	Descend the aircraft to 10,000 ft

Figure 7-31 Summary of Alternate and Emergency Operation

DISPATCH WITH INOPERATIVE PRESSURISATION EQUIPMENT

Whilst redundancy is designed primarily for safe flight an added advantage is that aircraft may be dispatched for flight with some components of a pressurisation system inoperative. There will be operational restrictions and flights will normally only be approved until the aircraft the returns to home base.

Authority to dispatch with inoperative equipment is detailed in the aircraft's Minimum Equipment List (MEL) publication. Examples of typical inoperative pressurisation equipment that may be carried over for continued aircraft operation are;

- A CPC/computer (if two are fitted),
- A safety relief valve
- Some indication faults

Note that the items listed above must be serviceable for ETOPS operation.

SPECIFIC PRESSURISATION PROCEDURES

INTRODUCTION

During flight the NORMAL procedures already discussed will be sufficient for normal operations. Occasionally events may occur that require specific pressurisation related ALTERNATE and EMERGENCY procedures to be carried out. They are;

- manual pressurisation,
- crew controlled depressurisation, and
- emergency descents.

MANUAL PRESSURISATION

Depending on crew selection both Outflow Valves may be operated together or individually. Manual pressurisation is difficult, particularly during climb and descent and constant monitoring and adjustment, even in the cruise, is required.

The outflow valve switches are momentary toggle switches and should not be held in either position longer than a moment or cabin rate of change will become excessive.

The rate of change is the best way to gauge your switch manipulations.

Remember that **OPENING** the outflow valves will cause the **cabin altitude** to go **UP** and **CLOSING** the valves will cause the **cabin altitude** to go **DOWN**. Refer to Figure 7-32.

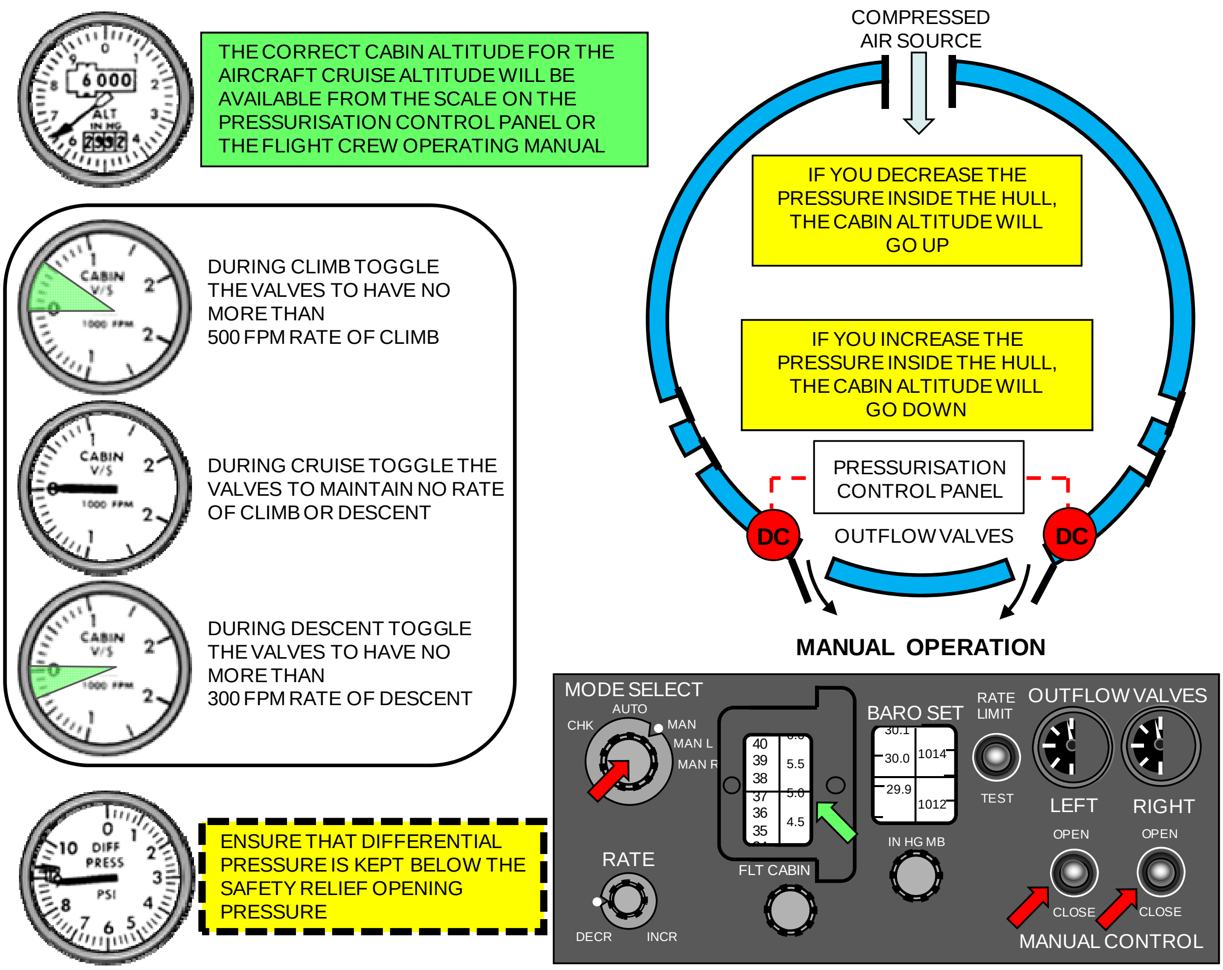

Figure 7-32 Manual Pressurisation Technique

CREW CONTROLLED DEPRESSURISATION

The Flight Crew Operating Manual provides a checklist (Smoke/Fumes Removal Checklist) to allow the crew to conduct a controlled depressurisation of the aircraft, to remove smoke or fumes.

Using the components previously described a depressurisation of the aircraft can begin as a descent is conducted. Obviously a full depressurisation cannot be completed until the aircraft is at 10,000 FT. When range is a consideration full depressurisation can be made at 15,000 FT provided crew and passengers are using supplemental oxygen.

To complete a full depressurisation it will be necessary to;

- set a cabin altitude higher than the aircraft altitude,
- set a landing altitude higher than the aircraft (max 14,000 FT), or
- open the outflow valves fully using MANUAL control.

In worst case scenarios the opening of cockpit windows and cabin doors may be required to clear intense smoke. Refer to Chapter 6, Air-conditioning Systems for an example procedure.

NOTE

At any time ALL of the air-conditioning units are turned off, the aircraft will begin depressurising as there are numerous small fixed vents continuously allowing cabin air to escape removing the fumes from toilets, galleys and the aircraft batteries.

EMERGENCY DESCENTS

When a serious decompression event occurs due to malfunction of the system or damage to the pressure hull an emergency descent should be initiated immediately.

Refer to Figure 7-33 for an example procedure.

EMERGENCY DESCENT		This procedure is representative of most aircraft although some may have slight variations such as extending gear during the descent profile
OXYGEN MASKS	ON	**First item for all aircraft**
CREW COMMUNICATION	ESTABLISH	Confirms that crew can communicate with oxy masks on
PASSENGER OXY SWITCH	ON	Backs up the automatic activation of passenger oxygen
DESCENT	ACCOMPLISH	Close thrust levers, Extend speedbrakes and Descend at VMO/MMO. Consider structural integrity and reduce airspeed if this is a factor.
TRANSPONDER	SET A7700	
ATC	ADVISE	Transmit a MAYDAY, Obtain clearance to target altitude
TARGET ALTITUDE	SET	The higher of MEA or 10,000/14,000 ft 10,000 ft is preferred unless range is a problem

Figure 7-33 Example Emergency Descent Procedure

Decompressions due to malfunction or damage are divided into three categories. They are;

- incipient,
- rapid, and
- explosive.

Incipient decompressions caused by pressurisation system failures are the most difficult to detect, and are usually caused by the failure of one or more of the system components, leading to a gradual increase in cabin altitude. This type of decompression will not cause serious discomfort to passengers or crew, unless the cabin is allowed to climb beyond acceptable levels of human tolerance. If a slow increase in cabin altitude is not noticed during regular scanning the first indication of a problem is usually the Cabin Altitude Warning alert at 10,000 ft.

Incipient decompressions can normally be rectified by the crew by selecting the other computer or following the alternate operating procedures for the system.

Rapid decompressions are usually caused by a failure of a pressurisation seal or similar component. This problem has also occurred in the past when a Ground/Air logic fault has determined that the aircraft is on the ground and therefore the outflow valves were driven to fully open. The cabin climbs at a rapid rate and will continue to climb to the actual aircraft altitude. Rates of cabin change may be as high as 3,000 to 4,000 FPM. This may cause some distress to passengers, particularly to those suffering from head colds or blocked sinuses.

<u>This type of decompression will require the crew to immediately initiate an emergency descent.</u>

Explosive decompressions are usually caused by a major structural component failing, such as a window or door blowing outwards. The change in cabin altitude is extremely rapid, and will cause severe pain and discomfort to crew and passengers. Temperature change will be very rapid, and a thick “fog” will normally form and last for several seconds. In extreme circumstances loose articles from within the cabin may get blown out through the hole. If the aircraft were flying at altitudes of 38,000 ft the time of useful consciousness is around 15 to 20 seconds.

<u>This type of decompression will require the crew to immediately initiate an emergency descent.</u>

In the circumstances described above it is obvious that oxygen masks must donned by the flight crew as soon as possible and some airlines recommend that when one pilot leaves the cockpit the remaining pilot should don the mask, just in case!

The ALTERNATE and EMERGENCY procedures previously described are important for understanding the aircraft pressurisation system and should be studied.

There are of course many other ALTERNATE and EMERGENCY procedures associated with the pressurisation of the aircraft. For interest they are;

- flying the aircraft depressurised,
- cargo door unlocked
- loss of Air Data Reference
- landing at high field elevations,
- cracked windscreen,
- tailstrike on take-off,
- bomb threat,
- emergency landing, and
- ditching.

FLYING THE AIRCRAFT DEPRESSURISED

An unusual situation but if required can be achieved easily in AUTO mode by selecting a cabin altitude higher than the aircraft cruise altitude. There have been occasions when high moisture content freight such as durian fruit, causes heavy condensation, which in turn activates the smoke sensors in the cargo bay.

To overcome this problem the crew climbs the aircraft depressurised until approximately 10,000 FT at which time the aircraft is slowly pressurised to the correct cabin altitude for the aircraft cruise level. In modern aircraft with no cabin altitude adjustment, <u>MANUAL pressurisation would be required.</u>

CARGO DOOR UNLOCKED

Some aircraft provide a procedure if the event of a cargo door becoming unlocked. Cargo doors are outward opening doors and subject to great load during pressurised flight. This procedure will involve descending the aircraft and depressurising down to and maintaining zero differential pressure to decrease the risk of door separation.

<u>MANUAL pressurisation will be required.</u>

LOSS OF AIR DATA REFERENCE

In very modern aircraft a total loss of air data references has serious repercussions as so many systems and indications depend on the information. The example procedure below only details the pressurisation requirements for this malfunction as there are many systems affected.

<u>MANUAL pressurisation will be required</u>.

Refer to Figure 7-34 for an example procedure.

LOSS OF ADR

- MODE SEL .... MAN
- MAN V/S CTL .... AS RQRD

Set the cabin altitude, according to the table below.

MAN CAB PR CTL
TGT V/S : CLIMB 500 FT/MIN
DESC 300 FT/MIN

A/C GPS ALT	CAB ALT TGT
410	8000
350	6500
300	5000
250	2500
<200	0

● **DURING FINAL APPROACH :**

- MAN V/S CTL .... FULL UP

CAUTION
Check that the outflowvalves are fully open, and that cabin altitude is at airfield elevation before opening the doors.

Figure 7-34 Example Loss of All Air Data Procedure

LANDING AT HIGH FIELD ELEVATIONS

The normal maximum cabin altitude allowed by most aircraft in AUTO mode is 8,000 FT and this is only when the aircraft is cruising at maximum altitude.

If a sector was being flown at FL 310 the cabin altitude could be as low as 5,000 FT. Upon descent to land the cabin altitude would actually start to climb if the landing field elevation was greater than 5,000 FT.

If the landing altitude is greater than the normal maximum of 8,000 FT the crew will have to MANUALLY enter the landing altitude to suit the situation. Refer to Figure 7-25 to observe the Landing Altitude Controls on a modern Pressurisation Control Panel.

CRACKED WINDSCREEN

The Flight Crew Operating Manual provides a checklist to deal with a cracked windshield or window. The objective here is to reduce the differential pressure to a safe level reducing the pressurisation load on the window.

<u>MANUAL pressurisation will be required</u>.

Refer to Figure 7-35 for an example procedure.

COCKPIT WINDSHIELD/WINDOW CRACKED

– MAX FL..230
– CAB PRESS MODE SEL ....MAN
– MAN V/S CTL..AS RQRD

Set the cabin altitude, according to the table below.

ΔP = 5 PSI	FL	100	150	200	230
	CABIN ALTITUDE	0	3000	6000	8000

• **When starting the final descent:**
– CAB PRESS MODE SEL...AUTO

Figure 7-35 Example Cracked Windshield Procedure

TAILSTRIKE ON TAKE-OFF

A tailstrike normally results in a return to land as soon as possible and it is important not to allow the aircraft to begin or continue pressurising as structural failure of the rear bulkhead may occur.

MANUAL pressurisation will be required.

Refer to Figure 7-36 for an example procedure.

TAILSTRIKE
Condition: **Fuselage contact with runway on take-off.**
Caution: **DO NOT PRESSURIZE AIRCRAFT DUE TO POSSIBLE STRUCTURAL DAMAGE.**
OUTFLOW VALVE MANUAL SWITCHES (Both)..ON
OUTFLOW VALVES MANUAL CONTROL...OPEN **Hold in open until both outflow valve position indicators show valves full open.**

Figure 7-36 Example Tailstrike Procedure

BOMB THREAT

The Flight Crew Operating Manual provides a checklist to deal with a discovered or suspected explosive device onboard the aircraft. It is always assumed that the device is altitude sensitive and therefore the cabin altitude should not be allowed to exceed the value at which the device was discovered or reported.

This procedure will require a landing at the nearest suitable airport and some manufacturers advise maintaining a maximum of 1 PSI cabin differential until landing whilst others a zero differential pressure.

In either case MANUAL pressurisation will be required until touchdown.

EMERGENCY LANDING

In large transport category aircraft when a sudden and unexpected immediate landing is required a specific checklist is provided.

This checklist is designed so that the crew can land the aircraft safely in a hurry and it eliminates all of the normal procedures that are conducted during approach and landing.

By selecting MANUAL (which uses the DC motor from a vital power supply) this will ensure the valves are opened even if normal power is lost. The pressurisation only items in the checklist are shown in Figure 7-37.

EMERGENCY LANDING
PACK CONTROL selectors (All)..OFF
OUTFLOW VALVE manual switches (Both).......................................ON
OUTFLOW VALVES manual control...OPEN [Hold in open until both outflow valve position indicators show valves full open. This ensures the aircraft is depressurised for opening passenger doors.]

Figure 7-37 Pressurisation only Items

DITCHING

After a successful ditching the aircraft should float with the cabin doors above the waterline as suspended wing mounted engines are designed to shear off to reduce weight.

To reduce the entry of water into the aircraft from below the waterline the “Ditching Procedure” will direct the crew (before ditching) to shutdown the air-conditioning units and close specific valves.

On most aircraft these will be the two outflow valves and the equipment/avionics bay extraction valve. Airbus aircraft provide a “DITCHING” switch which performs all these functions when selected. Refer to Figure 7-25.

Other aircraft will require multiple selections and MANUAL outflow valve operation in accordance with the checklist.

PRESSURISATION SYSTEM TERMINOLOGIES AND DEFINITIONS

The following table defines old and/or common terms that you may encounter with reference to pressurisation systems. Refer to Figure 7-38.

TERM REFERRED	DEFINITION
Auxiliary Vent	Another name for a Ram Air Valve.
Avionics Bay Exhaust Fan	All aircraft have electric fans extracting ambient cabin/cockpit air through the avionic/equipment bay to cool the avionics on the ground. The air exits through the valve used for smoke removal, the equipment bay overboard extraction valve. If all cabin and cargo doors happen to be closed the negative relief valves may open.
Cabin Exhaust Fans	Some aircraft have electric fans incorporated in the ducting just before the outflow valves. This ensures that the aircraft is being ventilated on the ground when air-conditioning is off. Ambient cabin air is extracted through the open outflow valves which assists in cooling any equipment operating in the cabin such as galley ovens, etc. If all cabin and cargo doors happen to be closed the negative relief valves may open.
Discharge Valve	Another name for an Outflow Valve.
Dump Valve	A valve used to dump pressurisation rapidly in an emergency. Some aircraft use the outflow valves as dump valves when the DUMP switch is activated. Modern aircraft use the avionics bay extract valve as the dump valve.
Hoop Stress	The term used that refers to the stress incurred by the fuselage structure during a pressurisation cycle.
Pressurisation Cycle	Each time a pressurised aircraft completes a sector, that is, from take-off to landing a pressurization cycle has occurred. Each aircraft has an allocated cycle life specified by the manufacturer. Cycles are recorded in the maintenance history of the aircraft.
Pneumatic Relay	A device only used in old pneumatically operated systems with dual outflow valves. The single controller reference pressure is relayed to each outflow valve individually.
Pressure Bump	The pressure change experienced after take-off when the outflow valves drive from fully open (on ground) towards close to begin pressurising the aircraft. Modern aircraft begin slowly pressurising before take-off to eliminate the pressure bump. The same pressure bump may be experienced on touchdown when the outflow valves drive fully open and once again modern aircraft eliminate this by landing pressurised and slowly depressurising during the landing rollout.

Figure 7-38 Pressurisation Terms and Definitions

PRESSURISATION SYSTEMS QUESTIONS

The following questions will examine your understanding of pressurisation systems and their operation. The answers may be found in the text or diagrams of this Handbook.

1. The generally accepted maximum cabin altitude for a large transport aircraft pressurisation system is;

    a. 10,000 ft.
    b. 6,000 ft.
    c. 8,000 ft.

2. The term ECS means;

    a. Environmental Control System.
    b. Engine Control System.
    c. Ecological Control System.

3. The percentage of oxygen in the atmosphere at all altitudes is approximately;

    a. 18 to 24% depending on temperature.
    b. 25%.
    c. 21%.

4. The common method of supply for pressurisation on large jet aircraft is;

    a. engine bleed air.
    b. APU bleed air.
    c. EDCs.

5. The first symptoms of hypoxia may begin to occur in humans above;

    a. 18,000 ft.
    b. 10,000 ft.
    c. 15,000 ft.

6. The minimum atmospheric pressure required to sustain life is;

    a. 1.7 PSI.
    b. 3.2 PSI.
    c. 2.7 PSI.

7. The generally accepted comfortable rate of altitude change for humans is;

    a. 300 fpm descending and 500 fpm ascending.
    b. 300 fpm ascending and 500 fpm descending.
    c. 500 fpm descending and 300 fpm ascending.

8. When air is compressed the percentage of oxygen;

- **a.** increase.
- **b.** decreases.
- **c.** remains the same.

9. Cruising at the maximum aircraft altitude with the pressurisation system in automatic the differential pressure is likely to be approximately;

- **a.** 6.0 to 7.0 psi.
- **b.** 8.0 to 9.0 psi.
- **c.** 9.0 to 10.0 psi.

10. The strengthened walls between pressurised and unpressurised areas within the structure of the aircraft are called;

- **a.** bulkheads.
- **b.** pressure bulkheads.
- **c.** pressure dividers.

11. If an engine is shutdown on a two engine aircraft during flight cabin pressurisation;

- **a.** will be seriously degraded and a descent to below 10,000 ft should be conducted.
- **b.** will be adequately supplied by the remaining engine.
- **c.** will operate adequately but at half flow rates.

12. Pressurisation supply enters the cabin area through;

- **a.** the air-conditioning units.
- **b.** the cabin inflow valves.
- **c.** the isolation valves.

13. The primary components of an aircraft pressurisation system are;

- **a.** CPC, ADC and outflow valves.
- **b.** PCP, CPC, and inflow valves.
- **c.** PCP, CPC and outflow valves.

14. The areas of an aircraft that are typically not pressurised are;

- **a.** wheel wells, nose radome, APU compartment and bulk cargo bay.
- **b.** wheel wells, nose radome, APU compartment and hydraulic service centre.
- **c.** wheel wells, nose radome, APU compartment and avionics bay.

15. Cabin doors and other exits are sealed against pressurisation loss by;

a. inflatable rubber seals.
b. their construction forming a plug into the fuselage structure.
c. large diameter round seals.

16. One of the requirements of a modern large aircraft pressurisation system is;

a. to have at least three air-conditioning units supplying air.
b. the ability to ventilate the aircraft if normal pressurization fails.
c. to be able to sustain a negative pressure differential of ± 25 PSI.

17. The device that operates the cabin outflow valves during manual pressurisation is;

a. the cabin pressure controller.
b. the pressurisation control panel.
c. the individual outflow valve's computer.

18. One of the requirements of an aircraft's pressurisation system is to have the;

a. ability to pressurise the aircraft using ram air only if required.
b. ability to clear smoke or fumes through the safety valves.
c. ability to depressurise the aircraft quickly if required.

19. If all engine bleed valves were closed in flight the aircraft would;

a. slowly lose pressurisation through vents and fixed outlets.
b. slowly increase differential pressure due to ram air input.
c. maintain the cabin altitude present when bleed valves were closed.

20. With the aircraft cruising at maximum service ceiling the outflow valves would be;

a. partially open.
b. fully closed.
c. partially closed.

21. With the differential pressure at a very low value, for example 0.5 PSI you would expect;

a. the negative relief valves to be opening.
b. the positive relief valves to be opening.
c. this to be normal just prior to touchdown.

22. Blowout panels are fitted to;

- **a.** preserve structural integrity.
- **b.** remove smoke from the cabin.
- **c.** relieve cargo door stresses.

23. The second item on most Emergency Descent checklists is to;

- **a.** don your oxygen mask and ensure the passengers have their masks.
- **b.** check communication between crew with oxygen masks fitted.
- **c.** declare a MAYDAY and initiate the descent.

24. When conducting MANUAL pressurisation to change the cabin altitude from 5,000 ft to 6,000 ft you would;

- **a.** set the landing altitude to 6000 ft.
- **b.** increment the outflow valves towards open.
- **c.** increment the outflow valves towards closed.

25. The purpose of the Ground/Flight switch fitted to some aircraft is to;

- **a.** switch from external power to aircraft power.
- **b.** begin pressurising during taxi to take-off.
- **c.** allow smoke removal by making the aircraft think it is on ground.

26. With the pressurization system in AUTO mode during descent you would expect to see the following indications;

- **a.** cabin alt decreasing, diff pressure decreasing and rate in ascent.
- **b.** cabin alt decreasing, diff pressure increasing and rate decreasing.
- **c.** cabin alt decreasing, diff pressure decreasing and rate in descent.

27. If the cabin altitude reaches 10,000 FT the altitude warning system will;

- **a.** sound an aural warning, illuminate a red light and drop the passenger oxy masks.
- **b.** sound an aural warning and illuminate a red light.
- **c.** sound an aural warning and illuminate an amber light.

28. Whilst conducting MANUAL pressurisation you notice that the cabin rate of descent is 750 FPM. You should take the following action;

- **a.** increment the outflow valves towards closed.
- **b.** increment the outflow valves towards open.
- **c.** adjust the rate back to a lower setting.

29. The indication or readout that should be used to gauge your incremental changes when conducting MANUAL pressurization is;

a. cabin vertical speed.
b. outflow valve position.
c. differential pressure.

30. Whilst conducting MANUAL pressurisation you notice that the safety relief valves are probably going to open. To ensure that they do not open you would;

a. increment the outflow valves towards closed.
b. select OVRD.
c. increment the outflow valves towards open.