Environmental

Like essentially all jets, the CitationJet operates in a very hostile environment. For numerous reasons, jets are typically operated at much higher altitudes than propeller driven aircraft. Jet engines are much more economical to operate at high altitudes than at lower altitudes due primarily to reduced fuel burn. However, the environment up high is brutally cold and the air up there is very thin. The human body could not survive these altitudes were it not for the elaborate environmental systems installed to keep the cabin pressurized and heated. The environmental systems on these aircraft are not there merely for our comfort. These systems are truly life support systems.

Three subsystems installed in the CitationJet work together to keep the cabin both comfortable and at a safe pressure altitude. One is the air delivery system which pumps conditioned air into the cabin. Secondly, the pressurization system controls the rate at which that air is leaked out of the cabin in order to maintain a safe cabin pressure altitude. And finally, these systems are backed up by an oxygen bottle and oxygen delivery system. The oxygen system is available primarily for emergency use.

At the heart of the air conditioning system are the environmental heat exchanger and Freon air conditioner. To understand the air conditioning process, let's begin by tracing the incoming air from the engine into the tailcone. There is a large volume of clean, compressed air available from the compressor section of each engine. This air is referred to as P3 or third stage bleed. The pressure and temperature of this air is highly variable, depending upon power setting. At high thrust settings, this air could exceed 800°F and 150 psi. 800 degree air is to hot to enter the tailcone. Consequently, a heat exchanger is mounted in each engine pylon, precooling this air down to something under 500°F. All bleed air allowed into the tailcone, whether it be environmental, anti-ice or service air, is cooled by this heat exchanger. A temperature sensor is located in the bleed air line downstream from the pylon heat exchanger, monitoring temperature of the air entering the tailcone. If the temperature of that air exceeds roughly 540°F, the associated amber BLD AIR O'HEAT annunciator will illuminate. The solution to a BLD AIR O'HEAT light is to reduce thrust on the offending engine until the light extinguishes.

Pylon Heat Exchanger, viewed from underneath

As engine thrust is reduced, both temperature and pressure of the P3 bleed reduces significantly. This change of bleed air pressure in response to thrust lever movement creates a potential source of discomfort in the cabin. If the inflow of air were allowed to vary significantly with thrust setting, the cabin would respond to thrust lever movement by descending as thrust is increased and climbing as thrust is reduced. To prevent uncomfortable oscillations in cabin pressure, this P3 bleed air is regulated by one or more flow regulating valves in these bleed lines. These valves are referred to as the pressure regulating and shutoff valves. The number and location of these valves is somewhat a function of CJ model and unit number. On some models, there are 2 shutoff valves one on each incoming bleed line and only one flow regulator on the pipe leading to the heat exchanger. On other models, the 2 flow control valves are also flow regulators. Under most circumstances, the outcome is the same. These flow control valves accept a variable pressure input from the engines and pass along a relatively constant outflow of 8 pounds per minute for the CJ and CJ2 and about 10 pounds per minute for the larger CJ3. As a result of these flow regulators, the cabin pressure does not vary significantly with thrust lever movement. Assuming a reasonably tight cabin, thrust lever movement should have no noticeable effect on cabin pressure. As a normal practice, power may frequently be reduced significantly during descent to keep airspeed under control. It would be uncomfortable and unacceptable to have the cabin climb as a result of this thrust reduction. On some models, these regulated bleeds are also designed to double their flow rates when only one bleed is operational, such as during single engine operation. This tends to smooth out the effects of losing a bleed or selecting a single bleed source for whatever reason.

L or R Flow Control and Shutoff Valve

In addition to being flow regulators, these flow control valves may also be shutoff valves. The normal position of the left and right bleed valves is open. Since it would not be desirable for these valves to close should an electrical problem occur, they are de-energized open and powered closed. In other words, they fail or are de-energized to their normally open position. These valves are controlled by a pressurization source selector switch, mounted on the environmental tilt panel. Selecting “BOTH” will result in no electrical power being placed on any environmental bleed valves. Left and right bleed valves will therefore be de-energized to their normally open position allowing left and right engine bleed into the cabin. Either bleed must be capable of pressurizing the cabin independently. Having both bleeds open provides an additional margin of safety should a system problem or an engine problem occur at altitude.

Moving the source selector from “BOTH” to “LEFT” will result in the right bleed valve being powered closed. Moving the source selector back to “BOTH” de-energizes the right bleed to the open position. Selecting “RIGHT” energizes the left bleed closed and selecting “BOTH” de-energizes the left bleed open. The other source selections available are “EMER”, “FRESH AIR” and “OFF”. The “EMER” position places 28VDC on all 3 environmental bleeds, causing all 3 to change state. This powers the left and right bleeds closed and powers the emergency bleed valve open. The emergency bleed valve is provided to enable pressurization of the cabin in the event of a loss of normal environmental air inflow for any reason. In addition, the “EMER” position powers the windshield anti-ice valve open, delivering air that would normally be provided to anti-ice the windshield into the cabin for pressurization. Whenever the emergency valve is open, an amber EMER PRESS ON annunciator light will illuminate. If possible, the windshield manual shut-off valves should remain closed while the cabin is being pressurized using emergency bleed. Opening the windshield manual valves will diminish the volume of emergency bleed air available to the cabin.

Selecting either “OFF” or “FRESH AIR” on the Air Source Selector places electrical power on the left and right bleeds, powering them closed. Since the emergency bleed is normally closed, this closes all environmental bleeds to the cabin, resulting in no pressurization inflow. In addition, the “FRESH AIR” position ducts air which normally ventilates the cabin heat exchanger, into the cabin. A fresh air blower provides some circulation of the cabin air. In practice, these positions are rarely used. The “FRESH AIR” position will also illuminate the FRESH AIR annunciator on the annunciator panel.

Flood Cooling Door, aft pressure bulkhead

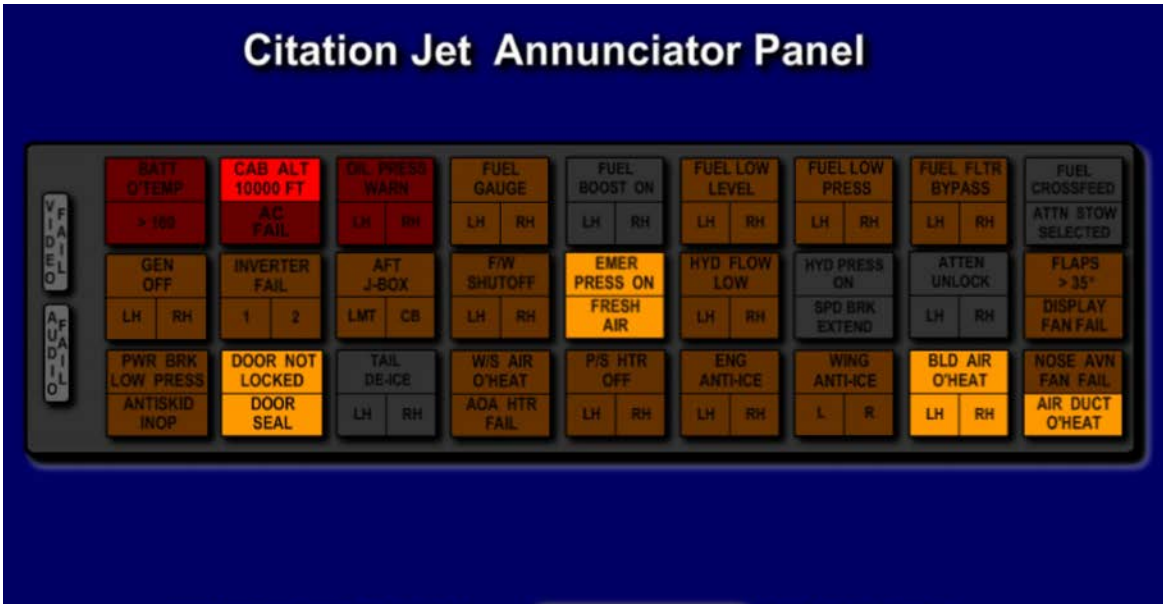
Pressurization Controller, CE-525

The temperature selector knob is located at the lower right corner of the controller on the tilt panel. Any position of this knob from about the 9:30 to the 5 o'clock position places the automatic temperature controller on line. The automatic mode strives to maintain a constant temperature in the cabin regardless of fluctuations in outside air temperature and other variables. Temperature is monitored in or near the cabin air return line by a cabin temperature sensor and that information along with the position of the temperature control knob is used to regulate the cooling airflow through the environmental heat exchanger. Selecting a warmer temperature reduces the volume of ambient cooling air forced through the heat exchanger. Selecting a cooler setting increases the volume of ambient cooling air forced through the heat exchanger. When the AIR COND switch is in AUTO, selecting warmer and cooler will also cycle the Freon air conditioner compressor off and on as needed. If the TEMPERATURE SELECT knob is twisted fully counterclockwise to the 9 o'clock position, this automatic temperature controller is de-activated and the regulator valve will not move unless the "MANUAL HOT - COLD " toggle switch is held up or down. The manual mode responds more quickly than the automatic mode but does require more input from the crew.

Cooling air intake for environmental heat exchanger

One of the amber annunciator lights illuminated below is the “AIR DUCT O’HEAT” annunciator light. This light indicates you have selected too warm of a temperature on the cabin temperature controller. An inadequate amount of cooling air is being forced through the environmental heat exchanger. A temperature sensor located in the environmental duct closes at roughly 300°F illuminating this “AIR DUCT O’HEAT” annunciator. The corrective action is to select a cooler temperature, cooling down the environmental duct.

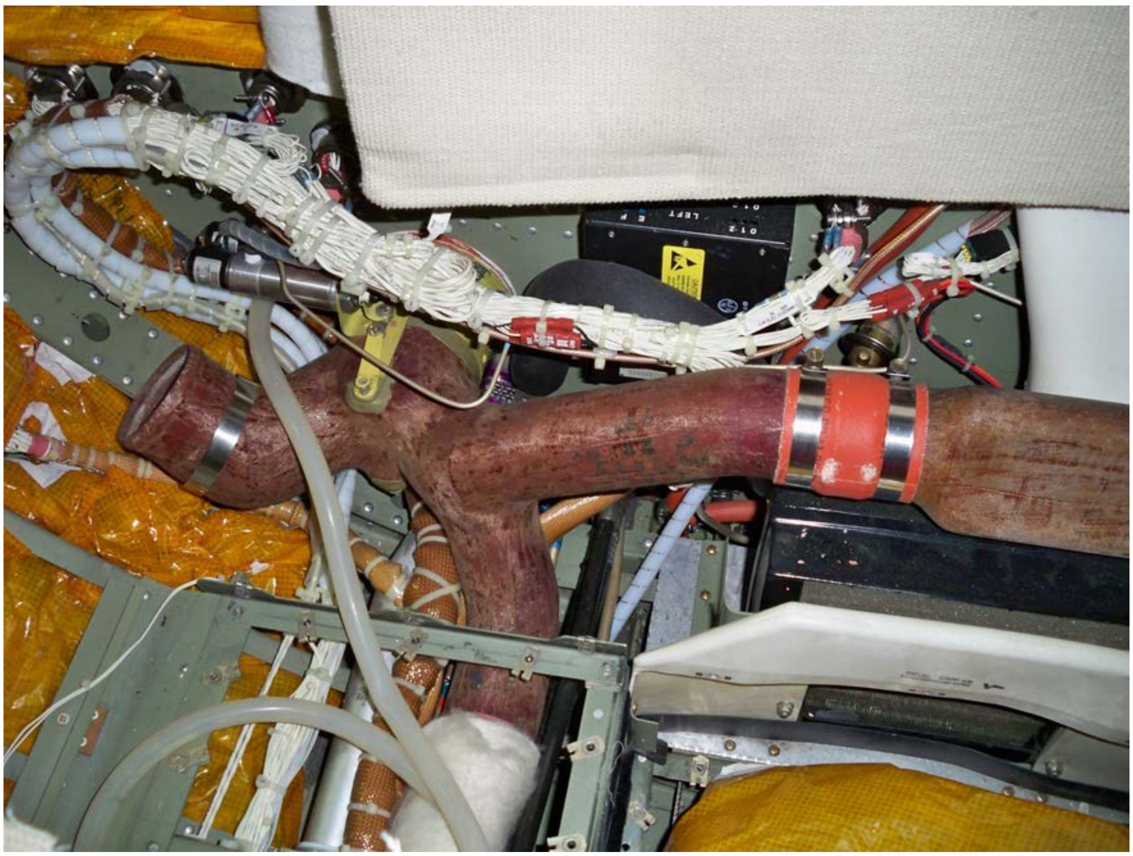
Lights illuminated on the above annunciator panel that have not been mentioned yet are “CAB ALT 10000 FT”, “DOOR NOT LOCKED” and “DOOR SEAL”.



Environmental Annunciators illuminated, CE-525

The CAB ALT 100000 FT annunciator simply states that the cabin pressure altitude is currently at or above 10,000 feet, well above the design maximum cabin altitude of 8000 feet. Assuming you are not landing at an airport at or above 10,000 feet, this is at the very least an abnormal situation and possibly a very serious emergency depending on the aircraft altitude. If the current aircraft altitude is around 10,000 feet, you are unpressurized, most likely because the Air Source Selector is turned to "OFF". If you are climbing, perhaps you should level off before the masks drop out of the ceiling and you have some explaining to do to the people in the back. Turning the Air Source Selector to "BOTH" should extinguish the light shortly and you should be able to resume your climb shortly. This light at cruise altitude is much more serious and as always, you should follow your aircraft's checklist which will probably suggest you don your masks and commence either a rapid or emergency descent.

The "DOOR NOT LOCKED" annunciator indicates that either one of the baggage doors are not key locked or that the lower forward pin of the main cabin door is not fully forward. If you are on the ground, fix it before you take off. If you are in flight, the checklist for this abnormal condition will likely include having everyone seated and buckled up, slow down and descend and possibly select a higher cabin altitude (9500 ft). These steps are designed to reduce the aerodynamic and pressure load on all doors that could contribute to this indication. Later CJs have individual lights for each door, simplifying the troubleshooting process. Earlier CJs have only one light with 4 switches wired in series enabling this light.



The photo above shows the possible paths incoming environmental air can flow through.

The "DOOR SEAL" annunciator indicates that the inflatable door seal has either deflated or is not pressurized to its normal operating pressure, 23 psi. There is a secondary non-inflatable door seal which is designed to back up the inflatable seal. However, the checklist for this indication will likely have you descend immediately to some specified altitude and then descend to below 14,000 feet as soon as possible. The crew may also be instructed to don oxygen masks as a precaution. A variety of conditions, one of which is freezing of moisture in the door seal plumbing, could cause this light to illuminate after some time at altitude and then extinguish as the aircraft descends into warmer air. Never-the-less, maintenance is required.

The environmental bleed lines are protected by check valves, preventing reverse flow overboard through an inoperative engine or compromised bleed line. These check valves eliminate the need to close a bleed on the CitationJet should an engine fail or should you choose to secure an engine for any reason. Check valves in these bleed lines will automatically close if they not held open by incoming air. Among other things, these check valves prevent compressed air from an operating engine from escaping overboard through a failed engine

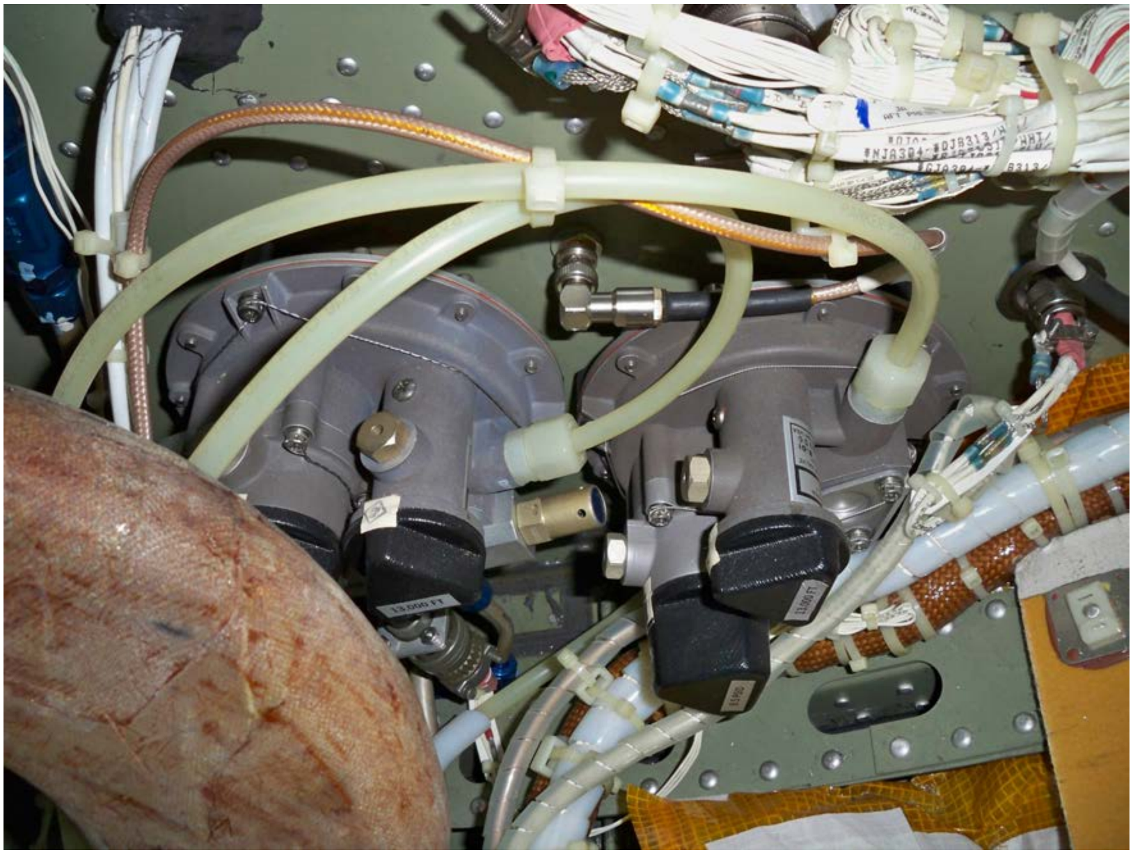
Whenever air is cooled significantly, moisture in that air is subject to condensing out and becoming liquid moisture instead of vapor. If not removed, this moisture will manifest itself in the form of mist or liquid being expelled from the wemacs in the cabin. This moisture must be removed. A centrifugal water separator in the discharge line of the cabin heat exchanger extracts this moisture and vents it overboard.
The mixture of dried and cooled air we have created leaves the water separator and continues its journey into the cabin through a checkvalve mounted on the aft pressure bulkhead. Should normal airflow into the cabin be lost due to an abnormal condition, this checkvalve will close, preventing the loss of environmental air out the opening. After passing through the aft pressure bulkhead, air enters one of a variety of different

diverter assemblies which deflect warm air to the foot warmers and cool air to the overhead outlets. We generally prefer warm air on our feet and cool air in our faces. In addition, warm air rises and cool air sinks, so this arrangement tends to keep the temperature in the cabin more even, minimizing hot and cold spots. The crew is also able to bias air volume to favor the cockpit or the cabin as desired as well as divert overhead air to the flood cooling vent on the aft pressure bulkhead by selecting "AFT FLOOD" on the environmental tilt panel.

Pressurization

The previous paragraphs of this chapter cover the delivery of breathable air into the cabin. This air delivery system provides a relatively constant inflow of air over a wide range of power settings. In order to insure safe operation should one bleed or one engine fail, much more air is pumped into the cabin than is required. This excess air must be vented overboard. The system in control of leaking this excess air overboard is the pressurization system.

Major components of the CitationJet's pressurization system consist of a Kohlsman Autoschedule Pressurization System controller, two outflow valves and the associated solenoids, switches, ejector and vacuum lines. Service air is vented into the cabin, some of which flows through an ejector creating vacuum. This service air and vacuum are used to manipulate outflow valves. The controller controls cabin pressure by applying either service air or vacuum to the outflow valves. The primary outflow valve is normally electrically controlled and pneumatically operated. The secondary outflow valve is pneumatically paralleled to the primary outflow valve and therefore will duplicate the primary valve action.



Outflow Valves

As is true with all transport category jets I am familiar with, the CitationJet cabin should never exceed 8000 feet pressure altitude under normal circumstances. At 10,000 feet, a red annunciator light labeled “CAB ALT 10000 FT” will illuminate, triggering the master warning lights as will any of the red lights on the annunciator panel. At a 13,000 +/-1500 foot cabin, (14,500 ft +/- 500 on the CJ2 and later), service air drives the outflow valves toward their closed position. This prevents the cabin from climbing further IF and only IF the cabin’s altitude is the result of a controller failure or mis-management, which has allowed excess vacuum to the outflow valves. And finally, if the cabin continues to climb above 13,500 feet (+/-600), oxygen masks will automatically drop from the ceiling in the main cabin. You can think of these 4 events as levels of protection provided to occupants of the aircraft by the environmental system. Summarized, the cabin should not normally exceed 8000 feet by design, at 10000 feet the red “CAB ALT” warning light illuminates, at 13000 feet cabin the altitude limiters close trapping air in the cabin and at 13,500 feet the passengers oxygen masks drop.

A highly simplified description of the pressurization controller follows.

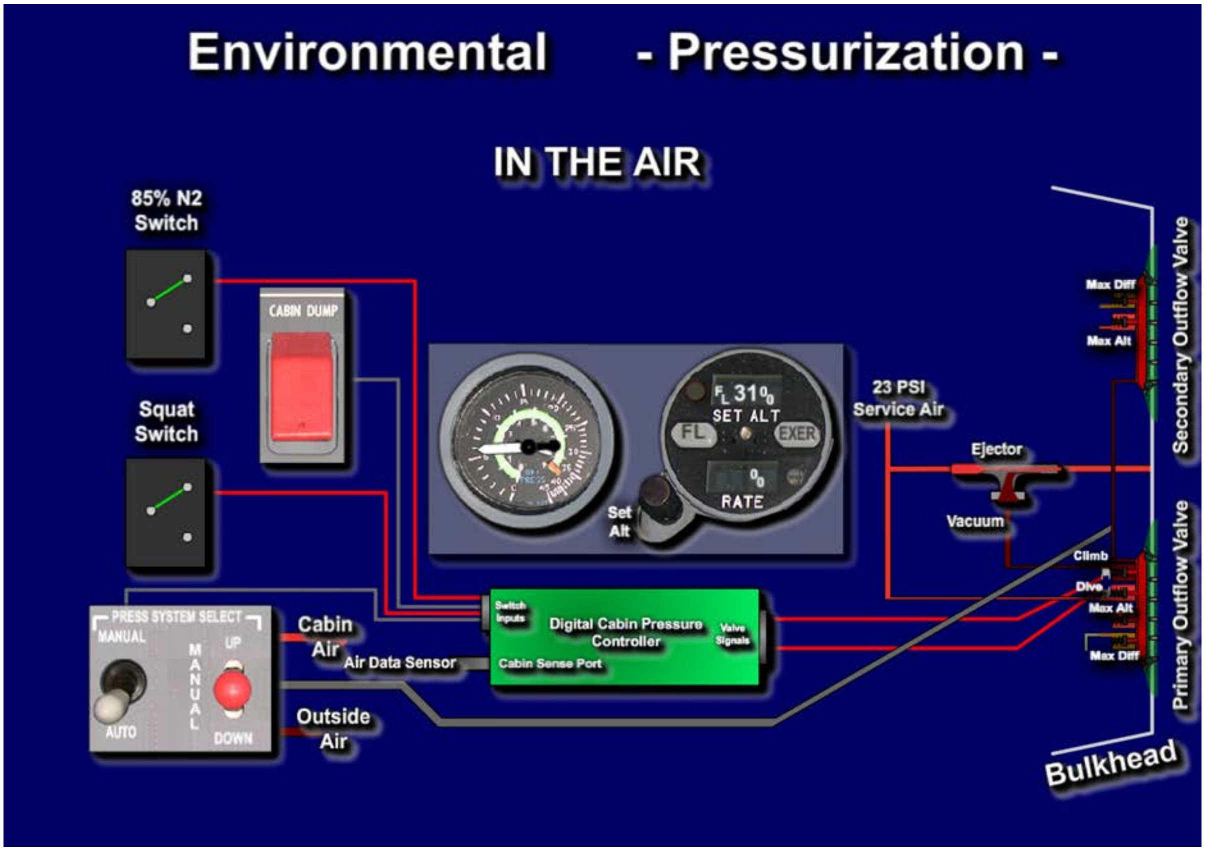
The Digital Cabin Pressure Controller receives inputs from numerous sources such as cabin reference pressure, current cabin and current outside pressures, pre-selected landing altitude, thrust lever position and the left main squat switch. During takeoff roll and in flight, these inputs are massaged by the controller and that information is used to operate the climb and dive solenoids on the primary outflow valve located on the aft pressure bulkhead. This outflow valve is pneumatically operated and electrically controlled. As mentioned earlier, the secondary valve is pneumatically plumbed in parallel with the primary outflow valve, causing it to duplicate the primary valve's movement. Service air is constantly provided to an ejector, or venturi in the cabin, deriving a vacuum. During the climb, this vacuum is metered by the climb solenoid to drive the outflow valve open. This has the effect of allowing the cabin to climb as the aircraft climbs, but at a slower and more comfortable rate. During the descent, 23 psi service air is provided to the dive solenoid to drive the outflow closed, descending the cabin. The rate at which the cabin climbs and descends is automatically controlled by the autoschedule controller, requiring no input from the crew.

The signal from the left main squat switch on landing opens the primary outflow valve on touchdown, assuring the cabin is unpressurized. The 85% switch on the thrust levers overrides the squat switch, allowing the cabin to begin pressurizing on the takeoff roll.

Pressurization Tilt Panel. Note "SET ALT" knob

Under most circumstances, crew input is limited to selecting the destination field pressure altitude, or 200 feet above on some early models, prior to takeoff. This is accomplished by turning the Set Alt knob till the destination field in hundreds of feet appears in the SET ALT window. The round amber annunciator light to the left of the altitude readout window must be extinguished in order for this fully automatic mode to be operational. The rate of climb and cabin pressure during cruise is managed by the controller with no additional input from the crew.

Should the Air Data Computer loose communication with the Digital Controller, the round amber annunciator light located to the left of the readout window will illuminate and the letters "FL", for Flight Level will appear. The FL readout will display the altitude programmed by the digital controller based on your input prior to takeoff. You can change that flight level setting by turning the Set Alt knob as desired and you will need to do so when you start the descent if not before. The field pressure altitude will then have to be set in the F/L window just as you would with an isobaric controller. The controller has reverted to isobaric mode. Should the communication link between the controlled and the ADC be restored, the annunciator light will extinguish, the FL will extinguish and the window should display the previous landing field pressure altitude you selected before takeoff.



Basic CJ Pressurization System Schematic

The PRESSURE SYSTEM SELECT switch is almost always placed in the "AUTO" or down position. In order for the two modes discussed above to work, this switch must be in AUTO, or down. Manual would be selected only in the event of an electrical failure of the system or the entire aircraft. In the MANUAL position, the cabin is raised by toggling the red MANUAL UP DOWN switch to the UP position. To descend the cabin, select the switch to the down position. This switch is referred to as the cherry picker and it must be moved in small steps to prevent rapid and uncomfortable changes in cabin pressure. Realistically, should you lose electrical power to the system, the order of business at hand is to go someplace where maintenance is available and land the airplane. I cannot imagine any circumstance under which you would climb an airplane with a crippled pressurization controller. I would consider that failure an emergency worthy of landing.

Oxygen System

The final component of the environmental trio is the oxygen system. The legal requirement for an oxygen system is spelled out in the Federal Aviation Regulations Part 91-211 entitled Supplemental Oxygen. Paragraph (a) applies primarily to unpressurized aircraft. Paragraph (b), entitled "Pressurized cabin aircraft" applies to the CitationJet. In part, it states that:

"(1) No person may operate a civil aircraft of U.S. registry with a pressurized cabin –

(i) At flight altitudes above flight level 250 unless at least a 10 minute supply of supplemental oxygen, in addition to any oxygen required to satisfy paragraph (a) of this section, is available for each occupant of the aircraft for use in the event that a descent is necessitated by loss of cabin pressurization; and

(ii) At flight altitudes above flight level 350 unless one pilot at the controls of the airplane is wearing and using an oxygen mask that is secured and sealed and that either supplies oxygen at all times or automatically supplies oxygen whenever the cabin pressure altitude of the airplane exceeds 14,000 feet (MSL), except that the one pilot need not wear and use an oxygen mask while at or below 410 if there are two pilots at the controls and each pilot has a quick donning type of oxygen mask that can be placed on the face with one hand from the ready position within 5 seconds, supplying oxygen and properly secured and sealed."

The next paragraph goes on to state that

"(2) Notwithstanding paragraph (b)(1)(ii) of this section, if for any reason at any time it is necessary for one pilot to leave the controls of the aircraft at flight altitudes above flight level 350, the remaining pilot at the controls shall put on and use an oxygen mask until the other pilot has returned to that crewmembers station."

Compliance with Paragraph (1)(i) above is assured by Cessna by installing the oxygen system in the aircraft at manufacture.

In plain English, paragraph (1)(ii) above states that above FL350, one crewmember up front must be sucking oxygen unless crew masks are in the quick don position. Some different style masks are pictured on the next page in their quick don position. Masks may remain in the quick don position till climbing above FL410 at which time one pilot must wear his or her mask. If operating single pilot, an oxygen mask must be worn by the pilot above FL350.

Time of Useful Consciousness Chart

ALTITUDE	AT REST	MODERATELY ACTIVE
FL 180	30 min	20 min
FL 220	10 min	5 min
FL 250	3 min	2 min
FL 300	75 sec	3 min
FL 350	45 sec	30 sec
FL 400	30 sec	45 sec
FL 450	15 sec	9 sec

NOTE: Cut these times in half for an "explosive" decompression.

EROS Oxygen Mask, stowed

Welding Helmet Style Mask, on hook

Oxygen Filler, nose baggage, right side

The oxygen system includes the bottle itself, which is installed in the nose under the floor of the baggage compartment on the right side. The capacity of this bottle could be either 22 or 50 cubic feet of oxygen. There are four tubes to the oxygen bottle.
They are:

- -the filler tube by which the bottle is serviced
- -a tube to the blow-out disc which will evacuate the bottle in the event safe pressure is exceeded
- -a tube to the pressure gauge in the cockpit
- -the regulated supply to the cabin.

Surprisingly, the bottle can be filled with the shut-off valve in the “off” position. The pressure gauge in the cockpit indicates pressure on the high-pressure side of the pressure regulator mounted on the bottle. In other words, the pressure gauge indicates bottle pressure regardless of the position of the shutoff valve. You cannot be assured oxygen is available to the cockpit by simply checking the pressure gauge. You must check for the flow of oxygen by testing or breathing through the masks.

Oxygen Bottle mounted in the nose

Oxygen leaving the bottle flows through a pressure regulator on the bottle itself and then to the connection for the crew masks. Crew masks are typically unplugged when the airplane is put away for the day to prevent leakage through the crew oxygen masks. Crew masks are equipped with microphones which are activated by switches on each crew armrests. Some crew masks are also available with smoke goggles. The pressure regulator on the bottle reduces oxygen pressure to 70 psi leaving the bottle. After the regulator, oxygen flows to a three position Oxygen Control selector located on the captain's left armrest. This selector allows the crew to prevent the flow of oxygen to the passenger masks by selecting "CREW ONLY". This position should only be selected if the airplane is being operated with no passengers, such as during a maintenance or ferry flight. "NORMAL" should be selected for normal operations. This position delivers oxygen to an electric pressure switch which senses pressure altitude in the cabin. If this switch senses

13,500 feet (+/- 600), 70 psi oxygen pressure will be delivered to the manifold servicing the overhead passenger masks. This pressure will cause the doors supporting the masks to swing open, dropping the masks into the cabin compartment. Each passenger mask will be supported by a cord referred to as a lanyard. These lanyards are each attached to a pin inserted into the oxygen supply line for that mask, preventing oxygen from flowing until pulled out or down by the passenger sitting at that station. This arrangement is similar to that on most commercial airliners we have all flown in. The idea is to conserve oxygen by preventing flow into unused masks. The final position available on the oxygen control valve is "MANUAL DROP". This position allows the crew to manually drop the masks in the cabin, perhaps due to smoke in the cabin or other emergency.

Oxygen Control Panel, left armrest

Should these masks be dropped accidentally, maintenance personnel must re-stow them. There is no procedure in either the Operations

Manual or the Aircraft Flight Manual by which the crew may re-stow these masks.

Oxygen panel, right armrest

To summarize the environmental ensemble, a relatively constant flow of compressed air is pumped into the tailcone through flow regulator valves. This air is then cooled, dried and delivered into the cabin through checkvalves. These checkvalves trap air in the cabin in the event of an environmental abnormality. Cabin pressure is controlled by metering this air overboard through outflow valves as required. The process as described is backed up by a supplemental oxygen system installed for emergency use. Properly maintained, the three systems described above work seamlessly to provide a safe and comfortable cabin with very little management effort from the crew. Always keep in mind that these systems not only keep us comfortable, they keep us alive.