# Pitot @-@ static system

A pitot @-@ static system is a system of pressure @-@ sensitive instruments that is most often used in aviation to determine an aircraft 's airspeed , Mach number , altitude , and altitude trend . A pitot @-@ static system generally consists of a pitot tube , a static port , and the pitot @-@ static instruments . This equipment is used to measure the forces acting on a vehicle as a function of the temperature , density , pressure and viscosity of the fluid in which it is operating . Other instruments that might be connected are air data computers , flight data recorders , altitude encoders , cabin pressurization controllers , and various airspeed switches . Errors in pitot @-@ static system readings can be extremely dangerous as the information obtained from the pitot static system , such as altitude , is potentially safety @-@ critical . Several commercial airline disasters have been traced to a failure of the pitot @-@ static system .

## Pitot @-@ static pressure

The pitot @-@ static system of instruments uses the principle of air pressure gradient . It works by measuring pressures or pressure differences and using these values to assess the speed and altitude . These pressures can be measured either from the static port ( static pressure ) or the pitot tube ( pitot pressure ) . The static pressure is used in all measurements , while the pitot pressure is used only to determine airspeed .

### Pitot pressure

The pitot pressure is obtained from the pitot tube . The pitot pressure is a measure of ram air pressure ( the air pressure created by vehicle motion or the air ramming into the tube ) , which , under ideal conditions , is equal to stagnation pressure , also called total pressure . The pitot tube is most often located on the wing or front section of an aircraft , facing forward , where its opening is exposed to the relative wind . By situating the pitot tube in such a location , the ram air pressure is more accurately measured since it will be less distorted by the aircraft 's structure . When airspeed increases , the ram air pressure is increased , which can be translated by the airspeed indicator .

### Static pressure

The static pressure is obtained through a static port . The static port is most often a flush @-@ mounted hole on the fuselage of an aircraft , and is located where it can access the air flow in a relatively undisturbed area . Some aircraft may have a single static port , while others may have more than one . In situations where an aircraft has more than one static port , there is usually one located on each side of the fuselage . With this positioning , an average pressure can be taken , which allows for more accurate readings in specific flight situations . An alternative static port may be located inside the cabin of the aircraft as a backup for when the external static port ( s ) are blocked . A pitot @-@ static tube effectively integrates the static ports into the pitot probe . It incorporates a second coaxial tube ( or tubes ) with pressure sampling holes on the sides of the probe , outside the direct airflow , to measure the static pressure . When aircraft climbs , static pressure will decrease .

### Multiple pressure

Some pitot @-@ static systems incorporate single probes that contain multiple pressure @-@ transmitting ports that allow for the sensing of air pressure , angle of attack , and angle of sideslip data . Depending on the design , such air data probes may be referred to as 5 @-@ hole or 7 @-@ hole air data probes . Differential pressure sensing techniques can be used to produce angle of attack and angle of sideslip indications .

## Pitot @-@ static instrument

The pitot @-@ static system obtains pressures for interpretation by the pitot @-@ static instruments . While the explanations below explain traditional , mechanical instruments , many modern aircraft use an air data computer ( ADC ) to calculate airspeed , rate of climb , altitude and Mach number . In some aircraft , two ADCs receive total and static pressure from independent pitot tubes and static ports , and the aircraft 's flight data computer compares the information from both computers and checks one against the other . There are also " standby instruments " , which are back @-@ up pneumatic instruments employed in the case of problems with the primary instruments .

### Airspeed indicator

The airspeed indicator is connected to both the pitot and static pressure sources . The difference between the pitot pressure and the static pressure is called dynamic pressure . The greater the dynamic pressure , the higher the airspeed reported . A traditional mechanical airspeed indicator contains a pressure diaphragm that is connected to the pitot tube . The case around the diaphragm is airtight and is vented to the static port . The higher the speed , the higher the ram pressure , the more pressure exerted on the diaphragm , and the larger the needle movement through the mechanical linkage .

### Altimeter

The pressure altimeter , also known as the barometric altimeter , is used to determine changes in air pressure that occur as the aircraft 's altitude changes . Pressure altimeters must be calibrated prior to flight to register the pressure as an altitude above sea level . The instrument case of the altimeter is airtight and has a vent to the static port . Inside the instrument , there is a sealed aneroid barometer . As pressure in the case decreases , the internal barometer expands , which is mechanically translated into a determination of altitude . The reverse is true when descending from higher to lower altitudes .

Main errors produced in altimeter ! ! 1 ) Blockage error 2 ) Lag error 3 ) Instruments error 4 ) Position error 5 ) Temperature error 6 ) Barometric error 7 ) Transonic Jump

### Machmeter

Aircraft designed to operate at transonic or supersonic speeds will incorporate a machmeter . The machmeter is used to show the ratio of true airspeed in relation to the speed of sound . Most supersonic aircraft are limited as to the maximum Mach number they can fly , which is known as the " Mach limit " . The Mach number is displayed on a machmeter as a decimal fraction .

### Vertical speed indicator

The variometer , also known as the vertical speed indicator ( VSI ) or the vertical velocity indicator ( VVI ) , is the pitot @-@ static instrument used to determine whether or not an aircraft is flying in level flight . The vertical speed specifically shows the rate of climb or the rate of descent , which is measured in feet per minute or meters per second . The vertical speed is measured through a mechanical linkage to a diaphragm located within the instrument . The area surrounding the diaphragm is vented to the static port through a calibrated leak ( which also may be known as a " restricted diffuser " ) . When the aircraft begins to increase altitude , the diaphragm will begin to contract at a rate faster than that of the calibrated leak , causing the needle to show a positive vertical speed . The reverse of this situation is true when an aircraft is descending . The calibrated leak varies from model to model , but the average time for the diaphragm to equalize pressure is between 6 and 9 seconds .

= = Pitot @-@ static errors = =

There are several situations that can affect the accuracy of the pitot @-@ static instruments . Some of these involve failures of the pitot @-@ static system itself ? which may be classified as " system malfunctions " ? while others are the result of faulty instrument placement or other environmental factors ? which may be classified as " inherent errors " .

= = = System malfunctions = = =

= = = = Blocked pitot tube = = = =

A blocked pitot tube is a pitot @-@ static problem that will only affect airspeed indicators . A blocked pitot tube will cause the airspeed indicator to register an increase in airspeed when the aircraft climbs , even though actual airspeed is constant . This is caused by the pressure in the pitot system remaining constant when the atmospheric pressure ( and static pressure ) are decreasing . In reverse , the airspeed indicator will show a decrease in airspeed when the aircraft descends . The pitot tube is susceptible to becoming clogged by ice , water , insects or some other obstruction . For this reason , aviation regulatory agencies such as the U.S. Federal Aviation Administration ( FAA ) recommend that the pitot tube be checked for obstructions prior to any flight . To prevent icing , many pitot tubes are equipped with a heating element . A heated pitot tube is required in all aircraft certificated for instrument flight except aircraft certificated as Experimental Amateur @-@ Built .

= = = = Blocked static port = = = =

A blocked static port is a more serious situation because it affects all pitot @-@ static instruments . One of the most common causes of a blocked static port is airframe icing . A blocked static port will cause the altimeter to freeze at a constant value , the altitude at which the static port became blocked . The vertical speed indicator will become frozen at zero and will not change at all , even if vertical speed increases or decreases . The airspeed indicator will reverse the error that occurs with a clogged pitot tube and cause the airspeed to be read less than it actually is as the aircraft climbs . When the aircraft is descending , the airspeed will be over @-@ reported . In most aircraft with unpressurized cabins , an alternative static source is available and can be selected from within the cockpit .

= = = Inherent errors = = =

Inherent errors may fall into several categories , each affecting different instruments . Density errors affect instruments metering airspeed and altitude . This type of error is caused by variations of pressure and temperature in the atmosphere . A compressibility error can arise because the impact pressure will cause the air to compress in the pitot tube . At standard sea level pressure altitude the calibration equation ( see calibrated airspeed ) correctly accounts for the compression so there is no compressibility error at sea level . At higher altitudes the compression is not correctly accounted for and will cause the instrument to read greater than equivalent airspeed . A correction may be obtained from a chart . Compressibility error becomes significant at altitudes above 10 @,@ 000 feet ( 3 @,@ 000 m ) and at airspeeds greater than 200 knots ( 370 km / h ) . Hysteresis is an error that is caused by mechanical properties of the aneroid capsules located within the instruments . These capsules , used to determine pressure differences , have physical properties that resist change by retaining a given shape , even though the external forces may have changed . Reversal errors are caused by a false static pressure reading . This false reading may be caused by abnormally large changes in an aircraft 's pitch . A large change in pitch will cause a momentary showing of movement in the opposite direction . Reversal errors primarily affect altimeters and vertical speed indicators .

#### Position errors

Another class of inherent errors is that of position error . A position error is produced by the aircraft 's static pressure being different from the air pressure remote from the aircraft . This error is caused by the air flowing past the static port at a speed different from the aircraft 's true airspeed . Position errors may provide positive or negative errors , depending on one of several factors . These factors include airspeed , angle of attack , aircraft weight , acceleration , aircraft configuration , and in the case of helicopters , rotor downwash . There are two categories of position errors , which are " fixed errors " and " variable errors " . Fixed errors are defined as errors which are specific to a particular model of aircraft . Variable errors are caused by external factors such as deformed panels obstructing the flow of air , or particular situations which may overstress the aircraft .

#### Lag errors

Lag errors are caused by the fact that any changes in the static or dynamic pressure outside the aircraft require a finite amount of time to make their way down the tubing and affect the gauges . This type of error depends on the length and diameter of the tubing as well as the volume inside the gauges . Lag error is only significant around the time when the airspeed or altitude are changing . It is not a concern for steady level flight .

## Pitot @-@ static related disasters

1 December 1974 ? Northwest Airlines Flight 6231 , a Boeing 727 , crashed northwest of John F. Kennedy International Airport during climb en route to Buffalo Niagara International Airport because of blockage of the pitot tubes by atmospheric icing .
6 February 1996 ? Birgenair Flight 301 crashed into the sea shortly after takeoff due to incorrect readings from the airspeed indicator . The suspected cause is a blocked pitot tube ( this was never confirmed , as the airplane wreck was not recovered ) .
2 October 1996 ? Aeroperú Flight 603 crashed because of blockage of the static ports . The static ports on the left side of the aircraft had been taped over while the aircraft was being waxed and cleaned . After the job was done , the tape was not removed .
February 23 , 2008 ? B @-@ 2 bomber crash in Guam caused by moisture on sensors .
1 June 2009 ? The French air safety authority BEA said that pitot tube icing was a contributing factor in the crash of Air France Flight 447 .