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FLIGHT INSTRUMENTS

CHAPTER 1 – ISA AND PITOT STATIC SYSTEMS

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INTRODUCTION TO PRESSURE INSTRUMENTS

THE INTERNATIONAL STANDARD ATMOSPHERE (ISA)

The environment in which an aircraft operates is the 'real atmosphere'. Our atmosphere varies in temperature, pressure, density and humidity from place to place on the earth's surface and above the earth's surface. In fact, the changes are so great that there are few common atmospheric conditions.

This makes measurement of aircraft performance and performance related indicators very difficult. To overcome this problem, the International Civil Aviation Authority (ICAO) developed the International Standard Atmosphere (ISA).

The International Standard Atmosphere is a theoretical atmosphere where pressure, temperature and density are defined. This stated set of conditions allows us to calibrate instruments and measure performance against a strict standard, a known reference. The ISA becomes the common basis for all aircraft pressure instrumentation. However, as ISA conditions are unlikely to exist in reality, we must make corrections for those conditions which are different from ISA.

Standards set by ICAO for ISA conditions include:

- Atmospheric pressure at Sea Level is 1013.25 hPa.
- Temperature at Sea Level is +15°C.
- Air temperature decreases at 1.98°C/1000'.
- Temperature decreases to -56.5°C at 36,089' then remains constant.

When studying the atmosphere we must understand that the atmospheric pressure is caused by the weight of air existing above. As air is compressible, the density of the air is greater near the earth’s surface and reduces with height. Pressure also reduces with height as less air exists above. The reduction of pressure with increase in height is non-linear because of the variation in density. For example close to the surface, atmospheric pressure reduces y 1 hPa for every 30 feet increase in height but at high altitudes, between 40,000 and 45,000 feet, pressure reduces by 1 hPa for every 125 feet increase in height.

This non-linear change of pressure with height is recognised by the International Standard Atmosphere and is therefore considered in the calibration of pressure instruments. Errors never the less arise in pressure altimeters because small pressure changes at high altitudes are difficult to measure accurately. The major source of error however is non-standard conditions, ie. atmospheric conditions that are different to those assumed in the calibration of the instruments. For example, mean sea level pressure can commonly vary between 950 and 1040 hPa, temperature at sea level may be between -40^{O}C and + 40^{O} C, temperature may remain constant or even increase with increase in height and pressure may reduce at a faster or slower rate than it would in ISA conditions. The errors that these variations produce will be considered as each pressure instrument is studied in turn.

PITOT AND STATIC SYSTEMS

STATIC PRESSURE

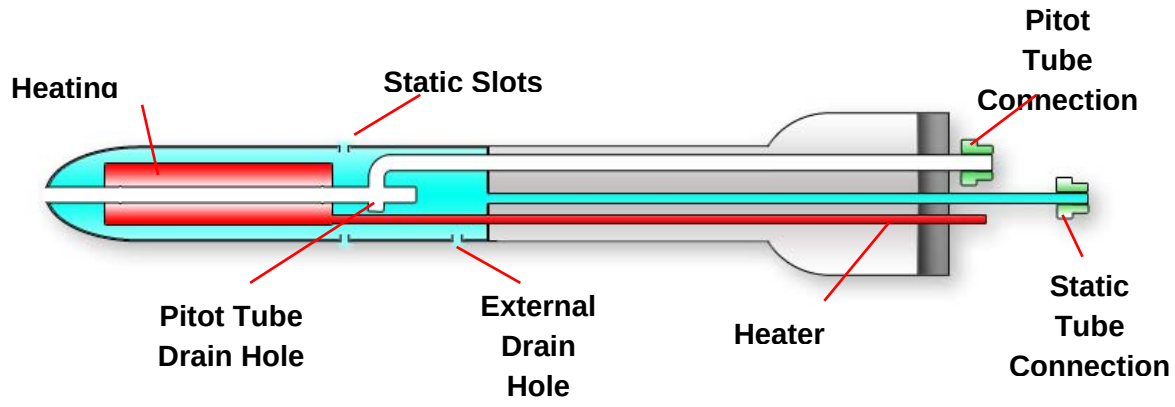
Static pressure is exerted at all times by the atmosphere and is not due to any motion. At sea level, this pressure is about 1013 hPa (14.7 P.S.I., 29.92 Inches/Hg). The static pressure acts in all directions at all times with exactly the same force in each direction. Every part inside and outside of an aircraft is subject to static pressure. As static pressure decreases with height, a measure of static pressure is a measure of height. To sense static pressure, static vents (or ports) are connected to the pressure instruments by a flexible tube.

PITOT PRESSURE

Pitot pressure is the total pressure collected in a forward facing open tube called the Pitot tube.

Static pressure exits in the Pitot tube, but as the aircraft moves though the air it experiences an additional pressure on all of its leading edges and inside the tube due to aircraft motion. The pressure exerted due to aircraft motion is dynamic pressure. The pressure existing in the Pitot tube is the sum of the static and dynamic pressures and is called total pressure.

The Pitot tube and the static vents are connected to the Airspeed Indicator where static pressure is cancelled leaving only dynamic pressure. Dynamic pressure is a function of airspeed so is considered a measure of airspeed.



On some aircraft, the source of both pressures is the combined Pitot/static head. However, most aircraft have a Pitot tube and separate balanced static vents.

COMBINED PITOT/STATIC HEAD

- Static and Pitot lines usually incorporate a water drain.
- Pitot heads are fitted with an electric heating element as an anti or de-icing device to reduce the risk of blockage should icing occur.
- Most aircraft have an alternate static vent in case the main static system becomes blocked.
- In large aircraft, left and right static sources, positioned each side of the forward section of the fuselage, are interconnected to reduce errors due to side-slip or yaw.

PITOT AND STATIC SYSTEM ERRORS

POSITION ERROR

Position error, also called pressure error, is caused by inaccurate sensing of Pitot and / or static pressures. Small errors are induced by the positioning of the Pitot head or static vent. Position errors are system errors and vary with the angle at which the sensor interacts with the airflow. The size of the error will vary with angle of attack and airspeed or Mach number.

The pressure instruments are all subject to position error. Position error is larger when alternate static is selected as this secondary system may, in the case of a light aircraft, sense static pressure from the engine bay or the cockpit. In heavy aircraft alternative static pressure may be obtained from a combined head or from an unbalanced static source.

MANOEUVRE-INDUCED ERROR

Manoeuvre Induced errors result from the disturbance of the airflow past the Pitot tube or static vent during and shortly after manoeuvres. The disturbances can cause errors in all the pressure dependent instruments which may be large, unpredictable but of short duration.

SYSTEM BLOCKAGES

Pitot *:* Covers, drains and heaters are provided to reduce the risk of blockages. Blockages could be caused by insects or icing.

Static *:* Covers (plugs) reduce the risk of blockages. Most modern aircraft are fitted with either an alternate static system or two completely separate static systems.

SERVICEABILITY CHECKS - PITOT STATIC SYSTEM

- Pitot cover and static vent plugs removed and stowed on board the aircraft, head alignment, security and condition checked.
- Pitot tube and static vents should be checked free from obvious obstructions such as insects.
- Pitot heater operative.