DOCUMENT
GSM-G-CPL.016

DOCUMENT TITLE

FLIGHT INSTRUMENTS

CHAPTER 6 – TEMPERATURE AND ANGLE OF ATTACK SENSORS

Version 1.0
September 2012

CONTENTS ..... PAGE

TEMPERATURE AND ANGLE OF ATTACK SENSORS

TEMPERATURE

Air temperature is one of the basic parameters used as an input to the Air Data Computer(ADC). In a static condition air temperature is relatively easy to measure using a common thermometer. However, air temperature in flight is affected by the adiabatic compression of the boundary layer air slowing down or stopping in relation to the aeroplane. This compression results in a temperature increase which is commonly known as "Ram Rise" . The ram rise due to full adiabatic compression may be calculated mathematically as a function of mach number. Therefore a useful temperature reading may be obtained in flight if the temperature measuring device registers:

a) no ram rise
b) complete ram rise
c) a constant factor of the ram rise.

STATIC AIR TEMPERATURE

SAT is the ambient air temperature. This temperature is often called the Outside Air Temperature (OAT) and is the temperature of the undisturbed or freestream air i.e. no ram rise.

RAM AIR TEMPERATURE

RAT is the ambient air temperature plus some ram rise. The proportion of ram rise is dependent on the ability of the equipment to sense or recover the adiabatic temperature rise. The sensitivity of the equipment to ram rise is expressed as a decimal which is called the "Recovery Factor". If a particular temperature sensor has a recovery factor of 0.8 the sensor will measure the ambient temperature plus 80% of the ram rise.

TOTAL AIR TEMPERATURE

TAT is equal to the ambient temperature plus all the ram rise. In other words, total air temperature is equal to RAT when the recovery factor is equal to 1.00.

SAT	Static Air Temperature	No Ram Rise
OAT	Outside Air Temperature	
Ambient Temp.	Atmospheric Temperature	
TAT	Total Air Temperature	Full Ram Rise
Tt	Total Temperature	
RAT	Ram Air Temperature	Some Ram Rise

RECOVERY FACTOR

Ct — the ability of the thermometer to pick up ram rise
eg. Ct 0.8 the probe will measure SAT + 80% ram rise

ERRORS IN THE MEASUREMENT OF AIR TEMPERATURE

Aircraft thermometers used for measuring air temperature are subject to the following sources of error:

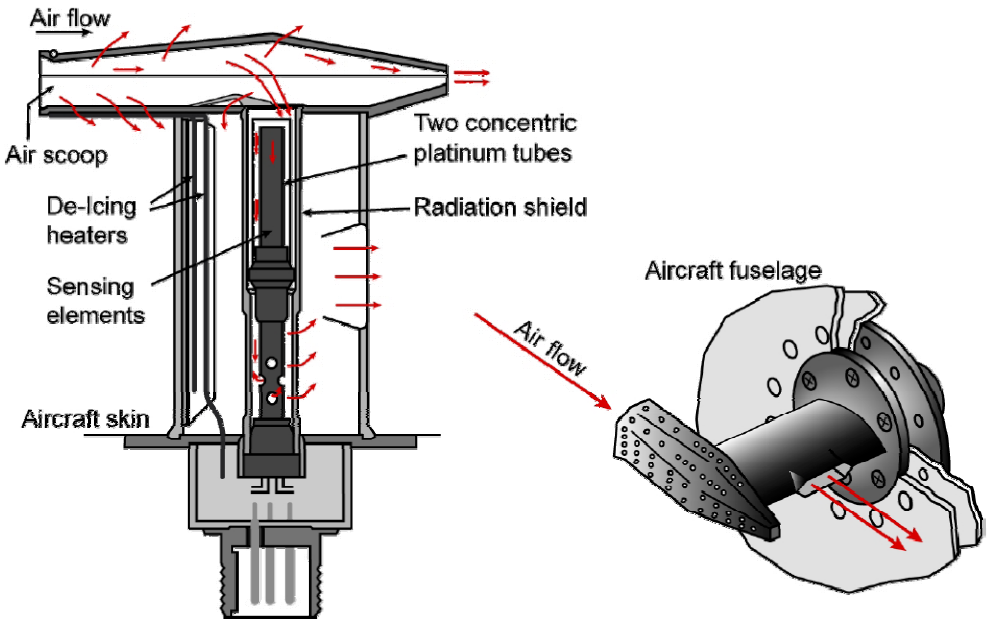
Instrument error is caused by imperfections in manufacture. Such errors are small and may be allowed for by applying a correction read from a card.

Environmental errors may result from the exposure of the sensitive element to direct solar heating and from the effects of ice accretion. The effects of icing can be reduced by incorporating a heater, from which the sensitive element is shielded.

Heating errors may be of the “ram rise” type, as previously described, or may result from frictional effects if the sensor is mounted on a flat plate flush with the skin of the aircraft.

TYPICAL TEMPERATURE SENSOR

The Total Air Temperature sensor or probe illustrated below consists of a hermetically sealed platinum resistance element, an air scoop and a de-icing element. The resistance of the platinum element changes with change of temperature causing a variation of the current flow to the indicating element which uses the ratiometer principle.



In a typical system one or more TAT probe is installed providing independent temperature data to each ADC. TAT is used by the Inertial Reference System (IRS), Flight Management Computer (FMC), Auto Throttle (A/T), Flight Control Computer (FCC) and the Air Temp/True Airspeed Indicator.

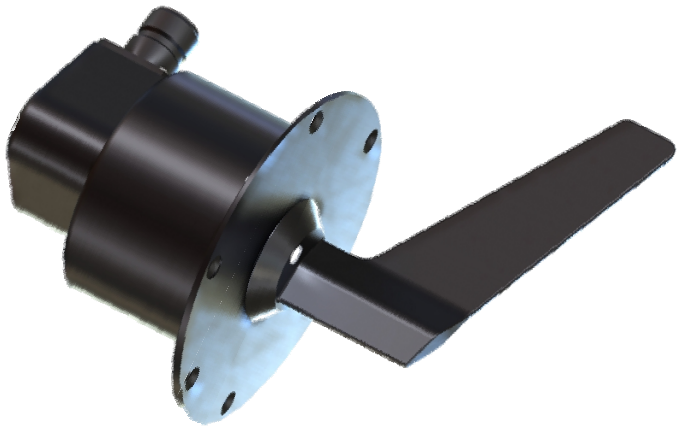
The in-flight TAT indication is comprised of outside air temperature (OAT) plus all of the ram rise.

ANGLE OF ATTACK SENSORS

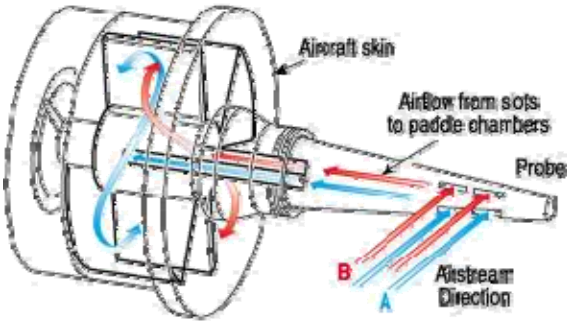
The sensors which measure angle of attack are commonly referred to as 'alpha probes'. They consist of an aerodynamic vane which trails according to the direction of the local airflow. The position of the vane determines the magnitude of an electrical signal produced by a syncho. The sensors are heated to prevent problems from icing.

The angle of attack measured by the vane is determined by the direction of the airflow relative to the longitudinal datum of the aircraft. The local airflow at the vane may not be representative of the free stream airflow so introducing an error. Corrections for airflow are produced within an Air Data Computer using a Mach N^O input.

Angle of attack may or may not be displayed. It is an input to the Air Data Computer, Stall Warning Computer, Wind Shear Detection System and the Flight Control Computer.
It should be noted that the Stall Warning Computer provides warning of an impending stall from inputs of angle of attack, configuration (flaps, slats etc.), thrust settings and airspeed. Along with aural warning , tactile warning is provided through the action of stick shakers which vibrate the control columns.



Some aircraft are fitted with **conical probes** in place of the moving vane sensor. The small conical shape protrudes from the side of the fuselage and is free to rotate about its axis of symmetry. The airflow passing over the conical surface enters two forward facing slots, and any pressure difference sensed by the slots is used to rotate the cone to equalize the pressures. The cone is then accurately aligned with the airflow, and its angular position is transmitted to the air data computer or angle of attack indicator.



The conical sensor is smaller and more robust than the aerodynamic vane sensor, and less susceptible to minor perturbations in the airflow