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MEASUREMENT OF AMBIENT AIR TEMPERATURE IN FLIGHT

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FOREWORD

In recognizing that the knowledge of ambient air temperature^{*} on board aircraft is exceedingly important not only for meteorological purposes, but also in connection with determining icing conditions, engine performances, and corrections to the airspeed indicator, and to the pressure type altimeter, ICAO requested certain Contracting States to submit reports on the results of their investigations concerning design of aircraft thermometers, their proper exposure on aircraft, and methods of correcting the readings in order to measure ambient air temperature in flight.

As a result of this request, several Contracting States have submitted reports on the subject. The reports received up to the 1st of January 1949, have subsequently been correlated and assembled by the ICAO Secretariat for the preparation of this circular.

* In this document the term "ambient air temperature" means the temperature of the undisturbed air surrounding an aircraft.

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SUMMARY

The ambient air temperature in flight is the temperature of the undisturbed air surrounding an aircraft. It is an important quantity used in weather and flight performance analysis. The measurement of ambient air temperature from an aircraft in flight is rather complicated, since most temperature measuring devices in the free air stream are influenced by the adiabatic compression due to the stopping or slowing down of the air. In addition, there are errors due to inherent inaccuracies in the design and construction of thermometers, instrumental time lag, radiation and conduction effects, air friction, thermometer element position on the aircraft, amount and form of moisture in the atmosphere.

However, the information obtained indicates that the ambient air temperature can be determined with sufficient accuracy for meteorological as well as for flight testing purposes, if accurate instruments and proper methods of exposure and correction are applied.

From the reports received it appears that no Contracting State as yet has attempted to standardize its equipment to measure ambient air temperature in flight and various types of thermometers are used and considered suitable for the purpose. The thermometer types in use include spirit; mercurial, bimetal and electrical thermocouples or resistance thermometers.

The methods of exposing thermometers to the air stream and of converting indicated air temperature to ambient air temperature are based in most countries on the same basic principles and appear to be applicable to any type of thermometer reported as being used at present.

In this circular the proper exposure of thermometers into the air stream and the relationship between the indicated air temperature and ambient air temperature is outlined in principle, and the design and installation of some particular aircraft thermometers is briefly described.



MEASUREMENT OF AMBIENT AIR TEMPERATURE IN FLIGHT

1.- INTRODUCTION

In order to determine the magnitude of the ambient air temperature in flight, that is, the temperature of the undisturbed air surrounding an aircraft, use is made of various types of thermometers mounted in a suitable position on the aircraft. The types of thermometers which have been reported as being used to measure the air temperature in flight are the following: spirit and mercurial thermometers with open and remote scales, electrical resistance and thermocouple thermometers and thermometers with bimetal temperature elements. Spirit and mercurial thermometers normally are simpler in construction and consequently appear to be more reliable. Mercury thermometers have their freezing point at approximately -35°C and cannot be used to measure lower temperatures. Bimetal and electrical thermometers appear to be less subjected to instrumental time lag.

Aircraft thermometers in most cases form part of an equipment unit which besides measuring temperatures is used to obtain other data such as the pressure and the humidity of the atmosphere.

In exposing aircraft thermometers into the air stream, care must be taken to ensure that the thermometer elements are not mounted in any position where air heated by the aircraft can affect it. In order to protect thermometers from direct sunlight and other radiation effects, special shields are provided or thermometers are mounted underneath the wing or fuselage. In order to expose thermometers as far as possible to the undisturbed free air stream they normally are mounted as far forward as possible towards the nose or leading edge of the aircraft and are so supported that they are in a position sufficiently remote from the skin of the aircraft to be outside the boundary layer.

In Section 3 of this circular, brief descriptions of the design and installation of some actual aircraft thermometers are given.

Irrespective of the type of thermometer and in spite of the most careful exposure of them, there exist several effects which may cause discrepancies so that the thermometer does not normally indicate closely enough the actual ambient air temperature. However, it has been found that the temperature readings obtained from thermometers which are suitably installed on present day civil transport aircraft are capable of being satisfactorily corrected to give a sufficiently good approximation of the true ambient air temperature.

In Section 2 of this circular, the relationship between ambient and indicated air temperature is outlined and the method reported by Contracting States for converting indicated airspeeds to ambient air temperatures is indicated in principle.

2.- RELATIONSHIP BETWEEN AMBIENT AIR TEMPERATURE AND INDICATED AIR TEMPERATURE

The influences which have been reported by Contracting States as having an essential effect on aircraft thermometer readings may be classified as follows:

- a) Instrumental errors;
- b) Effects of airspeed;
- c) Position errors;
- d) Time lag of instruments;
- e) Effects of atmospheric conditions.

A.- Instrumental Errors

The accuracy of any quantitative measurements may be limited by the inherent inaccuracy of the measuring equipment with which the measurements are made. From the information obtained it appears, however, that aircraft thermometers of any desired accuracy and range of application can be manufactured with such precision that instrumental errors are negligible or can be eliminated by applying to the readings corrections based upon calibration tests. Such corrections, if necessary, are normally supplied for each individual thermometer in the form of correction charts.