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Introduction

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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
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1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/ Figure/Table/Note	Type of comment	Comment (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	



DRAFT International Standard

ISO/DIS 8932-3

Meteorology — Radiosonde — Part 3: Laboratory test method for solar radiation error of temperature sensor in radiosonde

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2025-06-18

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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This document was prepared by Technical Committee ISO/TC 146, *Air quality*, Subcommittee SC 5, *Meteorology*.

A list of all parts in the ISO 8932 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Temperature and water vapour (i.e., humidity) are two of the basic atmospheric state variables and are important for developing weather and climate prediction models. To measure the temperature and humidity in upper-air, radiosondes are generally used. Radiosonde is an instrument intended to be carried by a balloon up through the atmosphere, equipped with devices to measure one or more meteorological variables such as pressure, temperature, humidity, and are provided with a radio transmitter for sending this information to an observing station.^[1] Radiosonde observations are often used in concert with other measurement techniques such as remote sensing using satellites to provide comparative data. For radiosonde-derived data to be useful, the measurement accuracy of radiosoundings is needed. From a metrological perspective, this measurement accuracy should be expressed in terms of uncertainty that is traceable to the International System of Units (SI).

Correction for solar radiation effects is critical for precisely measuring the actual temperature in the upper air. Since the temperature sensor is exposed to the outside air, the temperature measured by the sensor will be different from the air temperature due to solar radiation impacting the sensor. During daytime soundings, solar radiation heats the sensor. Therefore, all radiosonde temperature measurements show positive value radiation-induced errors in daytime. This is one of the main errors decreasing the accuracy of temperature measurements; thus, the measured temperature in soundings requires correction based on an algorithm or look-up table supplied by manufacturers.

There are many parameters that affect the radiation correction in soundings such as radiation flux, air temperature, air pressure, ventilation speed, solar elevation angle, and radiosonde orientation/motion with respect to sun. The radiative heating of sensors increases with a decrease in temperature (T), pressure (P) and ventilation speed (v), and, in general, the radiation correction increases as the radiosonde ascends. The decrease in these parameters (T , P , and v) results in a reduced heat transfer from the sensor to the air. With respect to the impact of ambient temperature on sensors, the reduction in thermal conductivity of air at low temperatures contributes to lowering the heat transfer coefficient; thereby, resulting in an increased radiation correction at such temperatures.^[2] The thermal conductivity of air plays a crucial role in influencing heat transfer at the boundary between the air and the sensor.

In radiosoundings, cloud cover and distribution as well as surface albedo also affect solar radiative heating. These conditions change in real time and are difficult to model in manufacturer's correction algorithms; thus, introducing uncertainty. The radiation correction is a complicated process which depends on multiple factors and parameters as well as different radiation correction algorithm features as applied by various manufactures which are proprietary and rarely disclosed. This document provides a testing method for measuring the radiation error for integrated radiosonde temperature sensors, using a limited number of samples from a batch of mass produced sensors.

The Standing Committee on Measurements, Instrumentation and Traceability (SC-MINT), one of the Technical Commissions and Research Board at the World Meteorological Organization, -- offers advice, recommendations, and promotes studies on the effective and sustainable use of instruments, such as radiosondes as well as offering methods for upper air weather observations. The SC-MINT Guide recommends that for temperature correction, solar radiation correction should be applied using software during data processing.^[1] Consideration of additional heating sources, the temperature sensor and supporting hardware are designed such that solar heating does not vary significantly as the radiosonde rotates in flight relative to the sun.

Despite recognising the importance of correcting sensor based meteorological temperature measurement, there is limited information in the SC-MINT Guide or other technical documents on test methods, procedures and related instrument details. Therefore, there is a need to publish a consensus procedure for evaluating radiosonde temperature error induced by solar radiation in an experimentally controlled way.

The procedure presented in this document provides laboratory setup technical requirements for conducting solar radiation test, test procedure for determining solar radiation error on radiosondes with various environmental and geometrical parameters, and a method for assessing uncertainties within test results. Temperature, pressure, ventilation, and radiation flux, as well as geometric parameters including sensor boom tilt angle and light illumination angle are evaluated over ranges that are varied to mimic in-flight conditions as experienced by radiosondes.

Note that when considering uncertainty in soundings, other factors such as temperature spikes due to patches of warm air coming off the sensor housing and the balloon, time-lag, and albedo should also be considered, as summarized in [Table 2](#) of Reference [3]. While all uncertainty terms affecting the results should be considered, this procedure specifically focuses on testing environmental and geometrical effects on the radiation correction.

The core procedure discussed in this document involves the SI-traceable generation of air ventilation speed in the test environment to simulate the ascendance speed of radiosondes. In addition, the solar irradiance, temperature, and pressure in the test cell should closely replicate those observed in upper air. To attain the required range variability of atmospheric parameters in the test setup, this testing method employs both an open suction-type wind tunnel and a closed-type wind tunnel as illustrative examples. These methods are chosen because of their traceability to the SI and validation by metrological and meteorological experts in testing radiosonde temperature sensors^[2,4].

Note that while the open suction-type wind tunnel using a combination of sonic nozzles and vacuum pump is based on Korean and US patents,^[5,6] the patent holder has granted a license, free of charge, to an unlimited number of applicants globally, without discrimination, and under reasonable terms and conditions. This license allows for the creation, use, and sale of implementations based on this ISO document. However, it's crucial to clarify that this ISO document does not detail the patented technique and is not an endorsement for use of patented material. Alternative equivalent procedures, employing different types of wind tunnel systems, can also be used to determine air ventilation speed at varying temperatures and pressures if they are SI-traceable and meet the data quality objectives of the application.

Meteorology — Radiosonde —

Part 3:

Laboratory test method for solar radiation error of temperature sensor in radiosonde

1 Scope

The document specifies a test method for estimating the magnitude of radiosonde temperature sensor warming, induced by direct solar radiation, based on variations in air pressure, temperature, ventilation speed, tilt angle of its supporting sensor boom, and light illumination angle on the boom through a laboratory evaluation. This document will describe the following:

- a) Technical requirements for a laboratory setup to measure the effect of direct solar radiation on radiosonde temperature measurement under simulated sounding conditions;
- b) A test procedure for estimating radiosonde temperature measurement errors due to direct solar radiation in the air pressure range of 3 hPa ~ 1,000 hPa, temperature range¹⁾ of -70 °C ~ 50 °C, ventilation speed range of 3 m·s⁻¹ ~ 7 m·s⁻¹ at a predefined irradiance (e.g. 1,000 W·m⁻² or higher), sensor boom tilt range²⁾ from 0° to 45° with respect to the air ventilation direction and the range of light illumination³⁾ angle from 0° to 90° with respect to the sensor boom plane;
- c) A method to evaluate uncertainty in the results under the test conditions.

The essential components of the laboratory setup are a climate chamber, wind-tunnel, a test cell, thermometers, pressure and vacuum gauges, a laser anemometer and a solar simulator. These components are summarised in [Clause 5](#). [Clauses 6–8](#) provide details on test preparation, the procedure for installing a radiosonde in the test cell, the operation of the laboratory setup, the experimental range and sequence, and data processing. In [Clauses 9](#) and 10, a method to evaluate and report uncertainty of the determined radiation errors on the temperature using the uncertainty propagation law, based on a mathematical model, is proposed.

NOTE 1 Since the test method is limited by the use of ground-based facilities, radiative cooling effect of radiosonde temperature sensors observed in stratosphere may not be reproduced and represented in the test result.

NOTE 2 The light source spectrum may be limited in the infrared (IR) region compared to that of the visible light solar spectrum. As recommended by the WMO guide by SC-MINT,^[1] the heat exchange in infrared radiation (IR) needs to be avoided by using sensor coatings that have low emissivity in the IR. Otherwise, the effect of IR can be underestimated in the test.

NOTE 3 Due to potential limitations in the number of test setups or laboratories capable of conducting this test, peer-reviewed reports or papers published online or offline resulting from research activities conducted by academia or meteorological institutes can be utilized as a test report when following this test procedure.

1) Currently, the lowest possible temperature of commercially-available climate chambers is approximately -75 °C. The temperature range can be adjusted base on the capability of the climate chamber used.

2) The tilt angle of the sensor boom can be adjusted depending on the space of the test cell. If tilting is not possible, a default angle of 0° can be used.

3) The light illumination angle can be adjusted depending on the ability of moving the light source or tilting the waveguide. If changing the illumination angle is not possible, a default angle of 90° can be used.

2 Normative references

The following documents are referred to in the text such that some or all of their content constitutes requirements under this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 17025:2017, *General requirements for the competence of testing and calibration laboratories*

ISO/IEC Guide 98-1:2009, *Uncertainty of measurement – Part 1: Introduction to the expression of uncertainty in measurement*

ISO/IEC GUIDE 98-3:2008, *Uncertainty of measurement — Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 99:2007, *International vocabulary of metrology — Basic and general concepts and associated terms (VIM)*

WMO No.182, 1992, *International Meteorological Vocabulary*

ISO 17713-1:2007, *Meteorology — Wind measurements — Part 1: Wind tunnel test methods for rotating anemometer performance*

ISO 15387:2005, *Space systems — Single-junction solar cells — Measurements and calibration procedures*

IEC 60050-713:1998, *International Electrotechnical Vocabulary (IEV) – Part 713: Radiocommunications: transmitters, receivers, networks and operation*

IEC 60904-9:2020, *Photovoltaic devices – Part 9: Classification of solar simulator characteristics*

ISO 9300:2022, *Measurement of gas flow by means of critical flow nozzles*

3 Terms and definitions

The following terms and definitions are specific to this standard.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <https://www.iso.org/obp>
- IEC Electropedia: available at <https://www.electropedia.org/>

3.1

radiosonde

instrument intended to be carried by a balloon through the atmosphere, equipped with devices to measure one or several meteorological variables (such as pressure, temperature, humidity), and provided with a radio transmitter for sending this information to the observing station

Note 1 to entry: A series of battery-powered telemetry devices that are suspended high in the atmosphere using a weather balloon, which measure atmospheric parameters, such as temperature and humidity, and transmit data to a ground system using radio frequencies.

Note 2 to entry: To ensure the traceability of radiosondes as a product under WMO control, it is necessary to obtain the WMO code (BUFR code 0-02-011). This WMO code must be unique for each radiosonde, and a single code must not be used for more than one type of radiosonde.

Note 3 to entry: The current requirements for threshold, breakthrough, and goal uncertainty in upper-air temperature measurements are specified in Observing Systems Capability Analysis and Review tool (OSCAR),^[7] which is a resource developed by WMO.

3.2

radiosonde body

housing of a radiosonde comprising a circuit board with measurement chips and a data transmission section with antennae and batteries