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Standard**

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**Meteorology — Radiosonde —
Part 2:
Laboratory test method for errors
in radiosonde humidity sensor
calibration**

**First edition
2026-05**

Meteorology — Radiosonde —

*Partie 2: Méthode d'essai en laboratoire pour les erreurs
d'étalonnage du capteur d'humidité dans la radiosonde*

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ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

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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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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

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 variables and are important for the initialization of numerical weather prediction and climate modelling. Radiosondes are widely used to measure atmospheric parameters such as humidity and temperature up to an altitude of approximately 40 km. A radiosonde is a balloon-borne instrument with several types of sensors for in situ profile measurements. A radio transmitter is used to send these data to the observing station.^[1] Radiosonde observations are often used in conjunction with other measurement techniques such as remote sensing satellites to provide comparative data. For radiosonde-derived data to be useful, the measurement accuracy of the radio soundings must be known. From a metrological perspective, this measurement accuracy must be expressed in terms of uncertainty that is traceable to the International System of Units (SI).

Previously, comparative soundings of dew-point hygrometers and radiosondes showed that radiosonde humidity sensors have a daytime dry bias resulting from solar heating and a time-lag error at low temperatures.^{[2],[3]} The dry-bias and time-lag error can be corrected in sounding systems by creating proper algorithms based on measurements of sensor temperature and response time, respectively. In addition, polymeric thin-film humidity sensors adopted by most radiosondes are known to produce systematic errors at the low temperature characteristic of the upper air environment if a calibration curve obtained at room temperature only is employed for low temperatures.^{[4],[5]} The capacitance of humidity sensors increases with adsorbed water vapour in thin films. While the adsorption capacity of the films for water vapour increases at lower temperatures, it does not fully compensate for the reduced water vapour pressure, leading to temperature-dependent behaviour in thin-film humidity sensors. Therefore, calibration of these sensors must be conducted at various temperatures. Thus, an essential prerequisite to resolve the above issues and to improve the measurement reliability of radiosondes is to calibrate the radiosonde sensors using ground-based facilities.^{[6],[7]}

The relative humidity generated by a laboratory setup or factory facility can be traceable to the SI via temperature, pressure, gas flow rate, and mass measurements related to determining water vapour pressure from either the humidity generator itself or the measurement of the generated humidity using calibrated precision hygrometers. The SI traceability of radiosonde humidity sensors must be established through factory calibration by manufacturers. This document is mainly focused on testing the calibration error of humidity sensors in radiosondes, which are randomly sampled from a series of products.

The Standing Committee on Measurements, Instrumentation and Traceability (SC-MINT) of the World Meteorological Organization (WMO) urges users to test selected samples of radiosondes under laboratory conditions to ensure that the calibrations supplied by the manufacturer are valid. Even if sensors can be produced in large batches to meet an agreed upon set of standardized performance checks, it is necessary for representative sensor samples, selected at random, to be checked more rigorously.^[8] This independent testing would further improve the reliability of radiosonde measurements by verifying the calibration results applied by manufacturers. While testing is crucial, the guide provided by SC-MINT only provides limited requirements for the test setup. These requirements describe the need for stability better than 1 %rh and systematic errors less than ± 1 %rh at the desired value. More detailed methodologies or test procedures for the testing of radiosonde humidity sensors in a relevant range of temperatures have not been reported.

The procedure presented in this document provides the technical requirements for essential laboratory setups that include a humidity generator, a test cell, a precision hygrometer, a pressure gauge, and a thermometer. The test procedure, including test preparation, installation of radiosondes in the test cell, operation of laboratory setups, and comparison between the reference and radiosonde relative humidity, is presented. The method for evaluating uncertainties associated with both the reference relative humidity and the radiosonde humidity sensor is also described.

The fundamental technique essential for this test involves the SI-traceable generation and measurement of water vapour pressure to determine the reference relative humidity and assess its associated uncertainty. Since humidity generators used in application of this document are capable of producing multiple dew-point and frost-point temperatures below the test temperature, the testing of sensors at several relative humidity levels at the test temperature while avoiding condensation can be accomplished. The water vapour pressure required for the reference relative humidity can be determined from frost or dew point temperature by either humidity generators or calibrated hygrometers as exemplified in Annex A. Dew-

point is the temperature, where water vapour is in equilibrium with liquid water at the same pressures.^[9] An example for obtaining multiple dew-point and frost-point values is presented using a saturator-based humidity generator. This approach is chosen because of its traceability, and its documented validation by metrological and meteorological experts in testing radiosonde humidity sensors.^{[4]-[8]}

Since calibration is valid at the time of calibration, this test can incorporate additional sources of uncertainty related to transportation and storage of the sensors, which can introduce additional uncertainty in the results. It's important to note that when considering uncertainty in soundings, other factors such as radiation dry bias and time-lag should also be considered, as summarized in Table 5 of Reference [3]. While all uncertainty terms affecting the results should be considered, the procedure in this document primarily focuses on testing a subset of the uncertainty factors outlined in Reference [3], specifically those related to testing temperature-dependent calibration corrections. In uncertainty analysis, the uncertainty of the test setup, reference devices, and other potential uncertainties affecting radiosonde measurements under static conditions are included in this test.

It is worth noting that while the saturator-based technique is founded on Korean and US patents,^{[10]-[12]} 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 important to state that this document is not solely based upon this patented technique. Alternative equivalent techniques, utilizing either different types of humidity generators or precision hygrometers, can also be employed for determining reference relative humidity if they are SI-traceable and meet the specifications required under this document.

Due to potential limitations in the number of test setups or laboratories available for 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.

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Meteorology — Radiosonde —

Part 2:

Laboratory test method for errors in radiosonde humidity sensor calibration

1 Scope

The document specifies testing procedures for determining calibration error for radiosonde humidity sensors sampled from mass production batches based on varying the levels of relative humidity at atmospheric upper-air temperatures using a laboratory setup. This document provides:

- a) technical requirements for a laboratory setup to evaluate the calibration errors of radiosonde humidity measurement;
- b) a test procedure for evaluating calibration error of radiosonde humidity sensors for a temperature range¹⁾ of -90 °C to 35 °C and for a relative humidity of 1 %rh to 100 %rh. Note, this document, is based upon relative humidity calculated by the percentage of water vapour pressure divided by saturation water vapour pressure over liquid water, not over ice, even at temperatures below 0 °C ; hence, the maximum relative humidity is less than 100 %rh below 0 °C ;
- c) a method for evaluating the uncertainty for the measured radiosonde humidity calibration errors.

2 Normative references

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

IEC 60050-713:2021, *International Electrotechnical Vocabulary (IEV) - Part 713: Radiocommunications: transmitters, receivers, networks and operation*

IEC 60068-3-6:2018, *Environmental testing – Part 3-6: Supporting documentation and guidance – Confirmation of the performance of temperature/humidity chambers*

IEC 60068-3-11:2007, *Environmental testing – Part 3-11: Supporting documentation and guidance – Calculation of uncertainty of conditions in climatic test chambers*

ISO/IEC Guide 98-1:2024, *Guide to the expression of uncertainty in measurement — Part 1: Introduction*

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*

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