A Proposal of Standard Calibration Laboratory for RICs

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Abstract

According to WMO, considered the need for regular calibration and maintenance of meteorological instruments to meet the increasing needs for high quality meteorological and hydrological data, the requirements of Members for standardization of meteorological instruments, the need for international instrument comparisons and evaluations, it was recommended to establish Regional Instrument Centres.

RICs are designated to carry out the following main functions:
(*a*) To keep a set of meteorological standard instruments linked with recognized international or national standards and to log their performance and elements of comparison;
(*b*) To assist Members of the Region in calibrating their national standard meteorological instruments or in comparing them with the standard instruments mentioned in *(a)* above and to keep the Members of the Region and the WMO Secretariat informed on the available standard instruments;
(*c*) To be prepared to certify the instruments' conformity with the standards, with reference to WMO recommendations;
(*d*) To organize instrument evaluations and comparisons, following standard methods;
(*e*) To advise Members of the Region concerned on their enquiries regarding instrument performance and the availability of relevant guidance material;

But up to now, there are no detail proposals for establishing a standard calibration. This paper will give three proposals to establish a standard meteorological metrology calibration laboratory for RICs.

1. General requirements for standard calibration instruments

The achievable uncertainties can be obtained with good instrument systems that are properly operated. The most important requirements for meteorological instruments are:

(*a*) Uncertainty (according to the stated requirement for the particular variable);

(*b*) Reliability and stability;

With regard to the above two requirements, it is important that an instrument should be able to maintain a known uncertainty over a long period.

In order to control effectively the standardization of meteorological instruments on a national and international scale, a system of national and regional standards has been adopted by WMO. In general, regional standards are designated by the Regional Associations and national standards by the individual Members. Unless otherwise specified, instruments designated as regional and national standards should be compared by means of travelling standards at least once every five years. Similarly, the instruments in operational use in a Service should be periodically compared directly or indirectly with the national standards.

The ability of individual sensors or observing systems to meet the stated requirements is changing constantly as instrumentation and observing technology advance. For some of the quantities, these uncertainties are achievable only with the highest quality equipment and procedures.

1.1 Temperature

LABORATORY STANDARDS

Primary standard thermometers will be held and maintained at national standards laboratories. A national meteorological or other accredited calibration laboratory will have, as a working standard, a high-grade platinum resistance thermometer, traceable to the national standard. The uncertainty of this thermometer may be checked periodically in a water triple-point cell. The triple-point of water is exactly defined and can be reproduced in a triple-point cell with an uncertainty of $1 \cdot 10^{-4}$ K.

Laboratory calibrations of thermometers should be carried out by national testing institutions or accredited calibration laboratories. For liquid-in-glass thermometers, a liquid bath should be employed, within which it should be possible to maintain the temperature at any desired values within the required range. The rate of temperature change within the liquid should not exceed the recommended limits and the calibration apparatus should be provided with a means of stirring the liquid. The reference thermometers and thermometers under test should be suspended independently of the container, fully immersed, and should not touch the sides. Sufficient measurements should be made to ensure that the corrections to be applied represent the performance of the thermometer under normal conditions with errors due to interpolation at any intermediate point not exceeding the non-systematic errors.

1.2 Air Pressure

Analysed pressure fields are a fundamental requirement of the science of meteorology. It is imperative that these pressure fields be accurately defined as they form the basis for all subsequent predictions of the state of the atmosphere. Pressure measurements must be as accurate as technology will allow, within realistic financial constraints, and there must be uniformity in the measurement and calibration procedures across national boundaries.

In view of the importance of accurate pressure observations, especially for aeronautical and synoptic purposes, and in view of the various possible errors to which mercury barometers are subject, all station barometers should be checked regularly by an inspector.

PRIMARY STANDARD BAROMETER

One possible primary standard for atmospheric pressure consists of a precision dead weight tester that produces a calibrated pressure related to the precision weights used and the local gravity field. This type of barometer is relatively simple and does not suffer from the problem of excessive drift of mercury barometers in a polluted environment.

The primary standard barometer may well be a high-quality mercury barometer specially designed for that purpose. The primary standard mercury barometer must have a high vacuum, contain very pure mercury with a well-known density maintained at a constant temperature, and be located in an environment where pollution effects are prevented. The barometer also needs a calibrated measure (scale) and an optical read-out facility. These types of barometers measure absolute pressure with high absolute accuracy, while dead weight testers are gauge

pressure measuring instruments.

1.3 Humidity

Humidity measurements at the Earth's surface are required for meteorological analysis and forecasting, for climate studies, and for many special applications in hydrology, agriculture, aeronautical services and environmental studies, in general. They are particularly important for their relevance to the changes of state of water in the atmosphere.

Principles involved in the calibration of hygrometers

Precision in the calibration of humidity sensors entails special problems, to a great extent owing to the relatively small quantity of water vapor which can exist in an air sample at normal temperatures, but also due to the general difficulty of isolating and containing gases and, more particularly, vapor. An ordered hierarchy of international traceability in humidity standards is only presently emerging.

An absolute standard for humidity (i.e. a realization of the physical definition for the quantity of humidity) can be achieved by gravimetric hygrometry. The reference psychrometer (within its limited range) is also a form of primary standard, in that its performance is calculable. The calibration of secondary, reference, and working standards involves several steps.

1.4 Solar Radiation

The various fluxes of radiation to and from the Earth's surface are amongst the most important variables in the heat economy of the Earth as a whole and either at any individual place at the Earth's surface or in the atmosphere. Radiation measurements are used for the following purposes:

(*a*) Study of the transformation of energy within the Earth-atmosphere system and of its variation in time and space;

(*b*) Analysis of the properties and distribution of the atmosphere with regard to its constituents, such as aerosols, water vapor, ozone, etc.;

(*c*) Study of the distribution and the variations of incoming, outgoing, and net radiation;

(*d*) Satisfaction of the needs of biological, medical, agricultural, architectural and industrial activities with respect to radiation;

(*e*) Verification of satellite radiation measurements and algorithms.

Such applications require a widely distributed regular series of records of solar and terrestrial surface radiation components, and the derivation of representative measures of the net radiation. In addition to the publication of serial values for individual observing stations, an essential object must be the production of comprehensive radiation climatologies, whereby the daily and seasonal variations of the various radiation constituents of the general thermal budget may be more precisely evaluated and their relationships with other meteorological elements better understood.

A RIC should satisfy the following conditions:

(*a*) It should possess and maintain a standard group of radiometers, which consists, of either three standard radiometers of the Ångström, silver-disk or absolute radiometer type or of two absolute radiometers;

(*b*) One of the standard radiometers should be compared at least once every five years against

the World Standard Group;
(*c*) The standard radiometers should be intercompared at least once a year to check the stability of the individual instruments. If the ratio has changed by more than 0.2 per cent and if the erroneous instrument cannot be identified, then a recalibration at one of the World Radiation Centres has to be performed prior to further use as standard;
(*d*) It should have the necessary facilities and laboratory equipment for checking and maintaining the accuracy of the auxiliary measuring equipment;
(*e*) It should provide the necessary outdoor facilities for simultaneous comparison of national standard radiometers from the Region;

1.5 Wind

Wind observations or measurements are required for weather monitoring and forecasting, for wind load climatology, for probability of wind damage and estimation of wind energy, and as part of the estimation of surface fluxes, e.g. evaporation, for air pollution dispersion and for agricultural applications. An accuracy for horizontal speed of 0.5 m s-1 below 5 m s-1 and better than 10 per cent above 5 m s-1 is usually sufficient. Wind direction should be measured with an accuracy of 5°.

A fully reliable calibration of cup, propeller, and vane anemometers is possible only in a wind tunnel; Wind-tunnel tests are useful for special projects or for type-testing new models.

2. Standard Configuration of Calibration Instruments

The configuration proposals are based on the two factors. One is the economic conditions of the RIC Member country, the other is upon the technology level of the present time.

2.1 Basic Level of Standard Instruments

The basic configuration proposal laboratory is designed to carry out the basic international comparison in RIC.

Table 1 The Basic Configuration Proposal For RIC's Laboratory

Elements	Class	Type	Range	Uncertainty
Temperature	secondary	Mercury	-40°C to +50°C	
		Platinum	-50°C to +50°C	0.025 °C
Humidity	secondary	Psychrometer	-50°C to +80°C	
Pressure	secondary	Mercury	500-1100hPa	
		Quartz	500-1100 hPa	$8.3+ 5.10^{-5}p$
Solar Radiation	secondary	Pyranometer	305-2800nm	$20W/m^2$
Wind	secondary	Pitot Tube	0-30m/s	1m/s
rainfall	secondary	Bottle		

2.2 Moderate Level of Standard Instruments

The moderate configuration proposal laboratory is designed to carry out the basic international comparison in RIC and among the RICs.

Table 2 The Moderate Configuration Proposal For RIC's Laboratory

Elements	Class	Type	Range	Uncertainty
Temperature	Primary	Platinum	-80°C to +50°C	0.025 °C
Humidity	Primary	Chilled Mirror Dew Point	10%RH-99%RH	1%RH
Pressure	Primary	Piston	500-1100 hPa	0.035hPa
Solar Radiation	Secondary	Pyrheliometer	305-2800nm	20W/m^2
Wind	Secondary	Hot Wire Anemometer	0-30m/s	1% or 0.5m/s
rainfall	Secondary	Mass set	25-500mm/h	

2.3 The higher Level of Standard Instruments

A higher configuration proposal of standard laboratory should consider more elements to be calibrated with much more higher uncertainty.

Table 3 A Higher Configuration Proposal For RIC's Laboratory

Elements	Class	Type	Range	Uncertainty
Temperature	Primary	Standard platinum resistance thermometer Platinum	-80 – 156^{o}C	0.002 °C
Humidity	Primary	Chilled mirror Dewpoint, Two-pressure humidity generator	1% RH to 99%RH (-50 to50°C)	1% of measured value
Pressure	Primary	Digital piston manometer	500 hPa to1200hPa	6 Pa
Solar Radiation	Primary	Absolute radiometer		Pyrgeometer 5.3% Pyrheliometer 1.5% Pyranometer 3 %
Wind	Primary	Pitot Tube and Differential Pressure Gauge, Hot wire Anemometer	0-75 m/s	0.1 m/s
Rainfall	Secondary	Flow bench	0-2000mm/h	1%
Ozone		Photometric O_3 analyzer		2 ppb
		Spectrophotometer		1%
Visibility	secondary	FD 12	10m-50 km	10%