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COMMISSION FOR INSTRUMENTS AND METHODS OF OBSERVATION
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STATUS OF INSTRUMENTS' TRACEABILITY IN NMHSs

Evaluation of the Survey on Maintenance and Calibration of Basic Meteorological Instrumentation

(Submitted by the Jérôme Duvernoy)

Summary and Purpose of Document

The document contains the evaluation of the Survey that was carried out in 2006 and that addressed the status of maintenance and calibration of basic meteorological instrumentation in NMHSs.

ACTION PROPOSED

The meeting is invited to take note the information provided in this document in developing recommendations to Members and to the Organization on how to improve calibration and maintenance in NMHSs to ensure that observations meet user requirements.

Evaluation of the Survey on Maintenance and Calibration of Basic Meteorological Instrumentation

Background

The Fifty-Seventh Executive Council, noting that accurate and timely measurements are prerequisite for successful natural disaster prevention and mitigation, requested the Secretary-General to strengthen the capacities of Members and those of the Regional Instrument Centres in observing practices and calibration of instruments. The Council also requested the Secretary-General that a survey be carried out to ascertain the capacity of Members' NMHSs in the areas of calibration and maintenance.

Following the EC request, a Questionnaire was developed by the CIMO Expert Team on RICs, Quality Management Systems and Commercial Instruments Initiatives (ET) in collaboration with the Association of Hydrometeorological Equipment Industry (HMEI) during the first session of the ET, Geneva, 4-7 April 2006.

The questionnaire was send on 22nd May 2006 requesting answers to be sent not later than the 15th of July 2006.

The cover letter of the Questionnaire on Maintenance and Calibration of Basic Meteorological Instruments expressed that a basic principle to guarantee a minimum required data quality, their worldwide compatibility and homogeneity is to ensure the traceability of measurements to the International System of Units (SI). This can only be achieved through a hierarchy of traceability of network measurements to the world standards through regular calibration of field instruments with working standards kept by the NMHSs and their regular comparison, through an unbroken chain of national, regional and international comparison, with the world standards. In the absence of calibration laboratories in NMHSs, the Regional Instrument Centres (RICs) and Regional Radiation Centres (RRCs) should provide the missing links to SI standards.

1. Global statistics and remarks

Send to all WMO members, 73 questionnaires were sent back to the Secretariat, that is equivalent to about 40 per cent. This very encouraging score indicates that calibration and maintenance concepts are important to NMHS.

RICs were of course in the centre of this questionnaire, the percentage of answers from RICs were more important and we obtain 75 per cent of filled questionnaires, if we take into account all nowadays centres (70 per cent at 15/07/06).

Due to the distance or the language, the percentage of answering was not equal in each Region, from 14 per cent in Region V or 25 per cent in Region IV to 50 per cent in Region VI.

Some confusion may be observed due to the definition of measurement standards. The term of 'National standard' has been understood as 'NMHS' measurement standards. The true answer to this question is available in the calibration report of the reference standard when this document is itself available or existing. This was a very good question to see the use of RIC or the competence of National Metrology Institutes. (see Annex 2 for a definition of the standards),

Globally, maintenance is done by 92 per cent of the members replying to the survey. Only a few per cent have subcontractors concerning maintenance, perhaps it is due to the fact that meteorological instruments are too specifics or too diverse.

Calibration scores depend on the parameter. The highest is pressure with 74 per cent of calibration performed, then temperature and humidity with respectively 62 and 56 per cent (see Annex 4). Very close to aviation security, pressure is also a core parameter in meteorology.

Below, reference standards are studied in purpose of delivering some guidance for NHMSs Laboratories.

2. Statistics by parameters

Presented in TECO 2006 at Geneva, two papers ([1] et [2]) give guidance for the choice of reference standards dealing with pressure, temperature and humidity. Based on these papers, some guidance is provided in Annex 1.

The analysis of the survey shows that some of the reference standards used by NMHSs are not

provided in the answers or not correctly described, and so can not be precisely classified in this report.

2.1. Pressure

2.1.1 Dead weight sensors

About 14 laboratories declare owning a dead weight sensor. They are spread all over the world, but none in Region III, only one in Region I, in Region IV and in Region V, 4 in Region II and 7 in Region VI. In terms of statistics, dead weight sensors are used by 20 per cent of laboratories. This figure is applying only to answering laboratories and in my opinion, the global number is surely nearer of 10 per cent or less.

2.1.2 Quartz barometers

Quite the same result concerning quartz barometers. 13 laboratories declare owning a quartz barometer (resonance). They are mainly located in Region I and VI with respectively 3 barometers and 9 barometers. The sensible sensor is provided by the same manufacturer.

2.1.3 Silicium diaphragm cell

Quite the same quantity is observed for silicium cell barometers. 12 laboratories use this barometer as reference or working standard (if no reference). There are regularly spread all over the world with about 2 in each Region except for Region V (0).

2.1.4 Capsule(s) or below

This paragraph takes in inventory mechanical or electromechanical devices based on capsule or below connected with an electronic reading. Only 4 services use this instrument. This instrument, when electrified, is derived from mechanical sensor. Due to mechanical problems, the achievable uncertainty is quite high.

2.1.5 Mercury

Most countries in developing areas or least developed countries use old mercury barometers. 26 per cent of the answers, actually 19 mercury barometers are still used as reference measurement standards. Mercury barometer is based on a physical principle and is so a perfect reference standard. This barometer is very stable in time conditioning to the fact that no mercury oxidation should appear. Most of laboratories use old “Fortin” barometer with an old calibration date, sometimes more than 20 or 30 years. The well known problem with this type of barometer is the ageing of the leather pocket containing the mercury. And the more important problem is the portability of this kind of instrument. To be used after a travel, they need a long delay (2 or 3 days) to achieve stability.

2.1.6 Regional statistics

Reference AR	Dead weight	Quartz	Silicium	Capsule	Mercury
I	1	3	2	2	6
II	4	1	5	2	4
III	0	0	2	0	4
IV	1	0	2	0	0
V	1	0	0	0	2
VI	7	9	1	0	3
Global (62)	**14**	**13**	**12**	**4**	**19**

Table 1: Reference standards used by NMHSs for calibration of pressure sensors

2.1.7 Partial conclusion

As requested, electronic barometers are calibrated regularly. Dead weight sensor or quartz barometer’s last calibrations were performed within the last 2 years. Only 3 instruments show a calibration date older than 5 years. We can imagine that these instruments are not really used as reference standards.

More crucial problem is the calibration of mercury barometer. This instrument cannot easily be carried from a national laboratory to the RIC. A travel standard is needed for this purpose.

Workshops, conferences, meetings can be the opportunity to do a calibration, but a quartz barometer or at least a silicium cell instrument is required as transfer standard.

Capsule barometer as barographs should be replaced by silicium cell barometers.

Finally, some countries have to deal with both mercury and electronic barometer. If theory is similar, calibration technique and system are quite different. Technicians should be trained for the new technology.

2.2. Temperature

Divided into four parts, the border between Standard Platinum Reference Thermometer (SPRT) and Platinum Reference Thermometer (PRT) is vague due to the lack of real indications in filled questionnaires and due to exotic instruments.

2.2.1 Fixed points

Only 3 laboratories are equipped with fixed points used as reference standards. These instruments are expensive, sometimes not easy to use. And the most significant problem comes from the fact that fixed points useful for meteorology are the triple point of Argon (-189.34 °C) and the freezing point of indium (+156.6 °C). This range is wide compared to the classic meteorological domain. These instruments are only of real use for the more demanding (and rich) laboratories. Of course uncertainty using fixed points is very low.

2.2.2 SPRT

The generally admitted reference standard used in temperature measurements is available in 19 NHMS, actually 26 per cent. Even if this sensor is relatively cheap, it needs a quite expensive apparatus to achieve low uncertainty. That means that some instruments classified as SPRT are perhaps only PRT. On the contrary, those having fixed points thermometers also have SPRT, but they are not classified as such.

2.2.3 PRT

10 countries are equipped with a PRT, handle system or lab instrument.

Adding all above paragraphs and sensors means that half of the countries are equipped with electronic devices.

2.2.4 Mercury

As pressure measurements, mercury is used as temperature reference standard in developing countries. For instance, these instruments disappears almost completely fro Region VI. And these sensors are still in use inside 20 countries. These instruments are easy to use but the problem is the reading of the measurement which can add a big error due to scale, meniscus and emergent stem.

2.2.5 Regional statistics

Reference AR	Fixed points	SPRT	PRT	Mercury
I	0	0	1	8
II	0	5	4	5
III	0	1	2	2
IV	1	0	0	1
V	1	0	0	1
VI	1	8	3	3
Global (52)	**3**	**19**	**10**	**20**

Table 2: Reference standards used by NMHSs for calibration of temperature sensors

2.2.6 Partial conclusion

Except in two cases, all calibration dates are younger than 4 years. Explanation can originate from two points. First, the temperature probe is more present in industrial domain, and secondly the instrument is more portable and can easily be sent to the calibration laboratory.

The problem with temperature calibration is more due to calibration generator and calibration environment. The homogeneity, the stability and the environment effects need to be known and managed to achieve an acceptable uncertainty.

The problem of the liquid (mercury, alcohol) thermometers is the reading errors. The problem of the electronic devices is the self heating. Both types are stable in time.

2.3. Hygrometry

Particularly for this parameter, generator and reference are both important and it is not easy to separated them. However, we do not have always both information in the questionnaire.

2.3.1 Generator

2 temperature or 2 pressure bench, climatic chamber and salt solution generator are the set of generator quoted in the questionnaire. The two latest are the most commonly used.

2.3.2 Dew point

Based on a physical principle this apparatus is difficult to use, expensive and needs a set of accessories and a generator such as a chamber or a bench. This instrument is used in 11 developed countries.

2.3.3 Salt solution

Based on the chemical properties of saturated or diluted salt in water, this generator may also be used as reference if used in adequate conditions. 7 laboratories are equipped with it. In absolute, salt solution is not a reference standard but only a generator and should be coupled with a calibrated capacitive hygrometer to avoid drift in measurement.

2.3.4 Psychrometer

The use of the wet thermometer associated with a dry sensor allows the calculation of relative humidity. The same countries listed for temperature measurement are found for humidity measurements, only 5 of them have another system or no humidity measure apparatus.

2.3.5 Capacitive hygrometer

Simple and cheap, the capacitive hygrometer or thermo-hygrometer attracted at least 8 laboratories for humidity measurements. The drawback is that this sensor needs periodic calibration due to its big temporal drift. Coupled with salt solution, this instrument can be a cheap system for humidity calibration.

2.3.6 Hair

Fortunately, this instrument is only used in a few set of countries (1 or 2). This sensor has an uncertainty of at least 5 per cent, even when calibrated properly.

2.3.7 Regional statistics

Reference AR	Dew point	Salt solution	Psychrometer	Capacitive	Hair
I	0	1	3	3	2
II	2	2	3	1	
III	0	0	3	0	
IV	0	0	1	0	
V	1	0	1	0	
VI	8	4	4	4	
Global (43)	**11**	**7**	**15**	**8**	**2**

Table 3: Reference standards used by NMHSs for calibration of humidity sensors

2.3.8 Partial conclusion

Once again, all calibration dates are younger than 3 years. Explanation came from the fact that this parameter is derived from temperature (dew point sensor, psychrometer, 2T bench) or less frequently from pressure (2P bench).If you have a reference concerning temperature measurement, you are able to calibrate hygrometry reference.

The problem with humidity calibration is due to calibration generator. Humid air is a mixture of dry air and moisture. If you have a leak of ambient air in your system or if you have an inhomogeneity of temperature inside your generator, the calibration error can be huge and undetermined.

The second problem comes from the capacitive sensor which needs a frequent calibration (at least every year) due to the time drift.

Then, hair hygrometer should be replaced quickly.

For a basic laboratory, salt solution generator associated with a capacitive hygrometer can be promoted for capacitive hygrometer calibration. To calibrate psychrometer, the two thermometers calibrations are needed.

Climatic chamber is useful for hygrographs calibration, but these instruments should be replaced. And homogeneity of chamber must be measured.

2.4. Wind

Only one third of the laboratories are equipped for wind vane calibration.

2.4.1 Hot wire

Only 5 labs use hot wire anemometer, 4 of them are located in Region VI. The other one is in Region V.

2.4.2 Relative pressure or Pitot Tube

12 countries are equipped with Pitot Tube or relative pressure sensors associated a priori with a wind tunnel but not expressly noted in the questionnaires. This instrument can be easily traceable to atmospheric pressure sensor.

2.4.3 Others

3 developed countries use more recent instrument based on sonic or laser Doppler measurements.

2.4.4 Regional statistics

Reference AR	Hot wire	Pitot Tube	Others
I	0	0	0
II	0	3	1
III	0	1	0
IV	0	0	0
V	1	1	0
VI	4	7	2
Global (20)	**5**	**12**	**3**

Table 4: Reference standards used by NMHSs for calibration of wind sensors

2.4.5 Partial conclusion

No crucial problem concerning wind calibration is noticed. Hot wires are used by developed country without traceability problems. Pitot tube or similar can easily be linked to pressure measurements.

2.5. Rain

Only two principles are use for this parameter, either a container or a balance. The container may be a calibrated bottle or jar or an electronic or manual burette.

2.5.1 Weight

7 Laboratories use a balance, or calibrated weights or equivalent system. 4 of them are located in Region VI, 1 in Region V and 1 in Region IV. This last one is a basic capability or specialized RIC.

2.5.2 Bottle

Distributed all over the world, 14 countries use a container for rain gage calibration. This system allows to achieve good uncertainties and is operable in situ.

2.5.3 Regional statistics

Reference AR	Weight	Bottle
I	0	3
II	0	5
III	0	1
IV	1	0
V	1	0
VI	4	5
Global (20)	**7**	**14**

Table 5: Reference standards used by NMHSs for calibration of rain sensors

2.5.4 Partial conclusion

No crucial problem concerning rain calibration. Weight or bottle are, if I may say so, calibrated for life and compared to the rain gage uncertainty, the calibration error of the reference is negligible. Those objects are commonly used in industry or chemistry.

An inter-comparison or rain gauge has been performed recently.

2.6. Sun radiation

Due to the fact that the World Radiation Centre (WRC) at Davos is responsible for maintaining the basic reference, the World Standard Group (WSG) of instruments and organizing international comparisons every five years, the standards of the Regional Radiation Centres are calibrated regularly.

A Regional Radiation Centre 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. There are 22 RRC and only 9 give and answer to the questionnaire, but 3 do not declare they have such equipment for solar radiation.

Globally 22 countries give answers and except for 2 or 3 cases the calibration was done recently (last inter-comparison campaign).

So WMO must continue the function of WRC as long as possible and the WSG must continue regular campaign.

Perhaps, as RICs, RRC should be reviewed regularly, specially if they do not participate regularly in comparison campaigns.

2.7. Others

2.7.1 Ozone

4 countries (1 Region II and 3 Region VI) declare an ozone measurement laboratories and wanted a comparison campaign.

2.7.2 Visibility and Cloud height

Respectively 4 and 5 countries are interested and equipped with calibration systems for visibility

and cloud height. Some are also interested in a comparison campaign. Due to the low number of interested participant, perhaps and inter-comparison is more justified.

2.8. Summary

Pressure	Dead weight	Quartz	Silicium	Capsule	Mercury
Global (62)	**14**	**13**	**12**	**4**	**19**

Temperature	Fixed points	SPRT	PRT	Mercury
Global (52)	**3**	**19**	**10**	**20**

Humidity	Dew point	Salt solution	Psychrometer	Capacitive	Hair
Global (43)	**11**	**7**	**15**	**8**	**2**

Wind	Hot wire	Pitot Tube	Others
Global (20)	**5**	**12**	**3**

Rain	Weight	Bottle
Global (20)	**7**	**14**

These tables can be compared to tables in Annex 1 coming from [1].

3. Use and needs of RIC

3.1. Calibration, comparisons

	RIC	Pressure	Temperature	Humidity	Wind	Rain	Solar Radiation
Yes	**43**	29	24	24	36	27	27
No	**18**	13	16	16	9	15	12

Table 6: Further need for calibration of instruments.

“In the absence of calibration laboratories in NMHSs, the Regional Instrument and Regional Radiation Centres should provide a missing link to SI standards.” Most of NMHS are interested by RICs, especially when calibration is missing inside the national service. But, practically, the RICs cannot stand in for any member calibrating all sensors. RICs are able to calibrate working standards, then NMHS calibrate their sensors. NMHSs do not need necessarily a modern calibration laboratory but they need at least a maintenance staff trained in calibration or they have to get a subcontractor to do this. The role of RICs is essential where national metrology is inadequate. In developed areas, the role of RICs is more into comparisons than into calibration. For instance, there is some demand for cloud height measurement comparison campaign inside Region VI or close neighbours. An inter-comparison of ozone measurements or visibility could also be organised by one of the four asking members.

3.2. Laboratory

	Organisation	Independence	Accreditation	ISO 9001	Future
Yes	50	23	13	6	41
No	11	34	0	0	8

Table 7: Availability and independence of the calibration laboratories.

If, generally, the calibration laboratory is identified into the organisation, this unit is frequently not clearly independent from the maintenance department. Quality management is crown by the success of accreditation or certification in roughly 20 countries (some are both certified and accredited), and in the

future, most of the countries want to achieve this quality level. However, sometimes the way to certification will be very hard and long. For accreditation versus ISO 17 025, the independence of the calibration laboratory must appear clearly in the organisation scheme.

4. Conclusions and foreseen

Pressure is crucial for aviation security and for weather forecast. 74 per cent of countries declare performing barometer maintenance and pressure calibration but traceability is missing or old in too numerous cases and more annoying we do not know the situation in non answering countries. As a result it could even be that the situation is worse in case those who did not reply to the questionnaire are not performing regular/proper calibration of their instruments.

The second TOR of RICs specifies that "A RIC must maintain a set of meteorological standard instruments and establish traceability of its own measurement standards and measuring instruments to the SI." Of course this requirement is also applicable to every national calibration laboratory. Mercury barometers cannot be carried easily, so travelling references are needed to perform calibration of those instruments at National Metrology Laboratories or at RICs.

On the same level, old instruments based on capsules or belows should be removed from laboratories and replaced by at least silicium cell sensors or quartz barometers. These instruments can be used as travelling standards. The Annex 1 can be used as guidance to calibration laboratories for purchasing reference instruments.

To train calibration operators in new electronic technology, specialized workshops on metrology should be organized within every Region. These workshops should highlight traceability requirements and teach electronic barometer calibration techniques. These workshops must be organised in well equipped RICs and preferably in Region I (south), Region II, III, IV (central America) and Region V. Such workshops have been previously held in Region I (northeast, west) and in Region VI. Workshops can be the opportunity of performing the travelling standards calibrations.

As well as workshops used for calibrations of reference standards, inter-comparisons could be organised in the shade of meeting, conference…

Noting that a RIC must regularly inform Members and report, on an annual basis, to the president of the Regional Association and to the WMO Secretariat on services offered to Members and activities done, I propose that the WMO website shows RIC capabilities. As proposed on the Cofrac website (see Annex 3) a document (web page) could summarise the RICs capabilities.

WMO may also organise e-meeting, e-group or e-forum on metrology intended for calibration laboratory managers. In the same way, specialised round tables can be organised in the shade of TECO.

5. References

[1] International vocabulary of metrology — Basic and general concepts and associated terms (VIM) JCGM 2008 Document produced by Working Group 2 of the Joint Committee for Guides in Metrology (JCGM/WG 2)
http://www.bipm.org/utils/common/documents/jcgm/JCGM_200_2008.pdf

[2] Y. Sha (China), et al.. http://www.wmo.int/pages/prog/www/IMOP/publications/IOM-94-TECO2006/4(1)_Sha_China.pdf TECO 2006 Geneva

[3] J. Duvernoy (France), et al.: http://www.wmo.int/pages/prog/www/IMOP/publications/IOM-94-TECO2006/4(3)_Duvernoy_France.pdf TECO 2006 Geneva

Annex 1

Guidance for the choice of reference standards

Extracted and update (*in italics*) from [2]

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	
Humidity	secondary	Psychrometer	-50°C to +80°C	0.025 °C
Pressure	secondary	Mercury	500-1100hPa	
		Silicium cell	*500-1100hPa*	*10-20 hPa*
		Quartz	500-1100 hPa	8.3+ 5.10-5p
Solar Radiation	secondary	Pyranometer	305-2800nm 20W/m2	
Wind	secondary	Pitot Tube	0-30m/s 1m/s	
rainfall	secondary	Bottle		

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	*Mercury*	*500-1100hPa*	
		Quartz	*500-1100 hPa*	*8.3+ 5.10-5p*
		Piston	500-1100 hPa	0.035hPa
Solar Radiation	Secondary	Pyrheliometer	305-2800nm	20W/m2
Wind	Secondary	Hot Wire Anemometer	0-30m/s	1% or 0.5m/s
rainfall	Secondary	Mass set	25-500mm/h	

Table 3 A Higher Configuration Proposal for RIC's Laboratory

Elements	**Class**	**Type**	**Range**	**Uncertainty**
Temperature	*Primary*	*Fixed points*	*-138°;156°C*	*0.002 °C*
Temperature	Primary	Standard platinum resistance thermometer Platinum	-80°C ; 156°C	*0.01°C*
Humidity	Primary	Chilled mirror Dew point, 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 O3 analyzer		2 ppb
		Spectrophotometer		1%
Visibility	secondary	FD 12	10m-50 km	10%

Annex 2

Definition of Standards

Calibration of instruments or measurement systems is customarily carried out by comparing them against one or more measurement standards. These standards are classified according to their metrological quality. Their definitions (ISO, 1993) are given in The Guide to Instruments and Methods of Observation, WMO-No. 8, Chapter 1, Part I, and may be summarized as follows:

1. *National standard*: A standard recognized by a national decision to serve, in a country, as the basis for assigning values to other standards.
2. *Reference standard*: A standard, generally of the highest meteorological quality available at a given location or in a given organization from which measurements made there are derived.
3. *Working standard*: A standard that is used routinely to calibrate or check measuring instruments.
4. *Transfer standard*: A standard used as an intermediary to compare standards.
5. *Travelling standard*: A standard, sometimes of special construction, intended for transport between different locations.

Primary standards reside within major international or national institutions. Secondary standards often reside in major calibration laboratories and are usually not suitable for field use. Working standards are usually laboratory instruments that have been calibrated against a secondary standard. Working standards that may be used in the field are known as transfer standards. Transfer standard instruments may also be used to compare instruments in a laboratory or in the field.

International vocabulary of metrology — ISO/IEC Guide 99-12:2007 International Vocabulary of Metrology – Basic and General Concepts and Associated Terms, VIM.

Annex 3

Example of technical sheets showing laboratory capabilities

cofrac

www.cofrac.fr
le portail de l'accréditation

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Page d'accueil

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METEO FRANCE - Laboratoire de Métrologie

7, rue Teisserenc de Bort

78195 TRAPPES CEDEX
Tél : 01.30.13.63.50 Fax : 01.30.13.60.20
web:www.meteo.fr
mail:eliane.jeanney@meteo.fr

Liste des accréditations

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  Etat : Accrédité
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- dossier n°2-1714
  annexe technique
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  Etat : Accrédité
  Accréditation valide jusqu'au : 31/10/2012

Cofrac, 37 rue de Lyon, 75012 Paris, tél. : 33 (0)1 44 68 82 20 - fax : 33 (0)1 44 68 82 21

Annex 3

Summary of replies received on the
Questionnaire on Maintenance and Calibration of Basic Meteorological Instrumentation
carried out in 2006

RA	**PREVENTIVE**		**PRESSURE**		**TEMPERATURE**		**HUMIDITY**		**WIND**		**RAINFALL**		**RADIATION**	
	MAINTENANCE		CALIBRATION		CALIBRATION		CALIBRATION		CALIBRATION		CALIBRATION		CALIBRATION	
	YES	*NO*	*YES*	*NO*	*YES*	*NO*	*YES*	*NO*	*YES*	*NO*	*YES*	*NO*	*YES*	*NO*
I	16	2	10	8	8	10	7	11	3	16	6	12	5	13
II	15	1	11	5	10	6	10	6	4	12	9	6	10	6
III	4	1	4	1	4	1	4	1	3	2	2	3	3	2
IV	6	0	5	1	3	3	1	5	2	5	3	3	1	5
V	3	0	3	0	3	0	3	0	1	2	3	0	3	0
VI	23	2	21	4	17	8	16	9	10	15	15	10	15	10
GLOBAL	**67**	**6**	**54**	**19**	**45**	**28**	**41**	**32**	**23**	**52**	**38**	**34**	**37**	**36**
%	**92%**	**8%**	**74%**	**26%**	**62%**	**38%**	**56%**	**44%**	**32%**	**71%**	**52%**	**47%**	**51%**	**49%**