Infrastructure Commission (INFCOM)

Standing Committee on Measurements, Instrumentation and Traceability (SC-MINT)

Expert Team on Quality, Traceability and Calibration (ET-QTC)

Metrology in Meteorology

Part-4: Infrastructure of a standard laboratory (2)

Drago Groselj (ARSO)

WORLD METEOROLOGICAL ORGANIZATION

Content

1. **Pressure**
2. Precipitation
3. Wind speed and direction
4. Solar radiation
5. Quality system

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Pressure

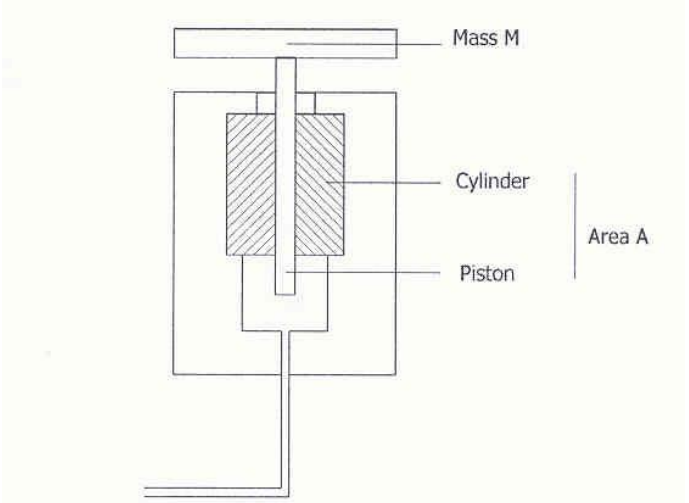
Again - two ways:

- Primary pressure standard which covers meteorological pressure range for your country. Typically a pressure balance or dead weight gauge.

Pressure balance consists of a piston/cylinder assembly and a set of masses. Piston/cylinder assembly define the area A and set of masses the force F.

The piston is vertical and slides freely in the cylinder.

The force generated by the pressure on the area is balanced by the masses loaded on the piston's head and submitted to the gravity.



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$$p = (1 - L \cdot p) \cdot k_n \cdot \frac{g_l}{g_n} \cdot \frac{N}{N_K} \cdot \frac{\rho_m - \rho_a}{\rho_m - 1{,}2} \left[1 - (\alpha_p + \alpha_c) \cdot (t - 20)\right] + \mu + \rho_a \cdot g_l \cdot h$$

Par.	Description	Value
L	Pressure distortion coefficient of the piston cylinder assembly	<0.000 Pa^{-1}
p	Pressure measured	[Pa]
k_n	Conversion coefficient of the piston cylinder given in the calibration certificate.	20.00270 $kPa \cdot kg^{-1}$
g_l	Local gravity – measured	9,80615880 $m \cdot s^{-2}$
g_n	Normal gravity	9.80665 $m \cdot s^{-2}$
N	Readout on the dynamometer DPG	[dig]
N_k	Nominal coefficient of the dynamometer	100 000 dig/kg
ρ_m	Mass density – stainless steel AISI 304 L	7920 $kg \cdot m^{-3}$
ρ_a	Air density during calibration of the dynamometer.	[$kg.m^{-3}$]
1.2	Normal air density	1.2 $kg.m^{-3}$
α_p	Thermal expansion coefficient of the piston	$0.45.10^{-5}$ ° C^{-1}
α_c	Thermal expansion coefficient of the cylinder	$0.45.10^{-5}$ ° C^{-1}
t	Temperature of the piston cylinder assembly	[° C^{-1}]
μ	Residual pressure	[Pa]

Advantage	Disadvantage
Pressure balances are traceable to measurements of mass and length and therefore more directly to national standards.	Measurements must be corrected for temperature, local gravity and air buoyancy which can increase probability for errors as the corrections are applied.
They have good long term stability	Time consuming operation for day-to-day routine work.
High accuracy, high reproducibility, reliable and stable instrument.	

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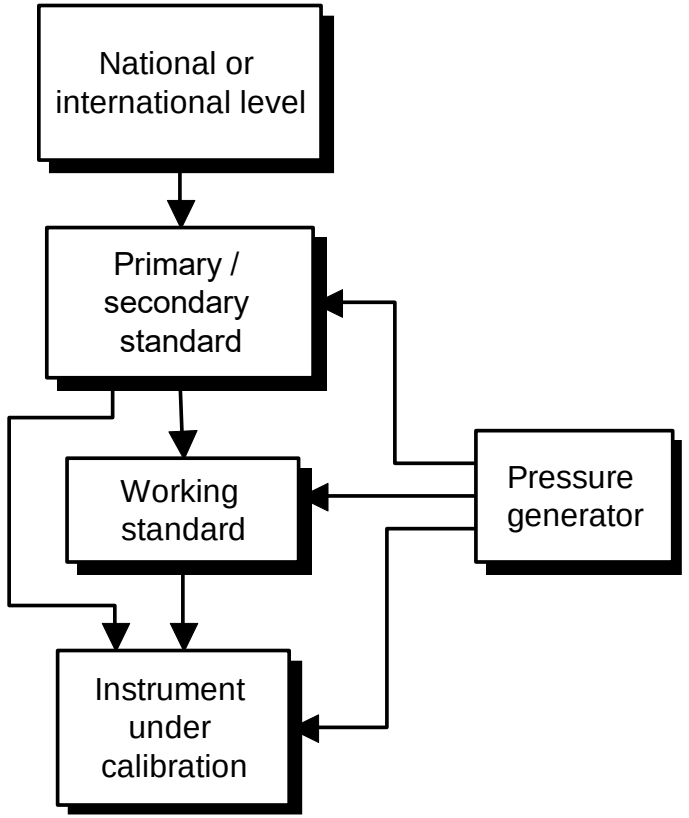
Pressure

- Second way is to use **reference electronic barometers** and have them calibrated at the NMI/RIC/accredited laboratory and dessiminate value to your working standard.
- High stability pressure controller to provide representative pressures to measure is needed.



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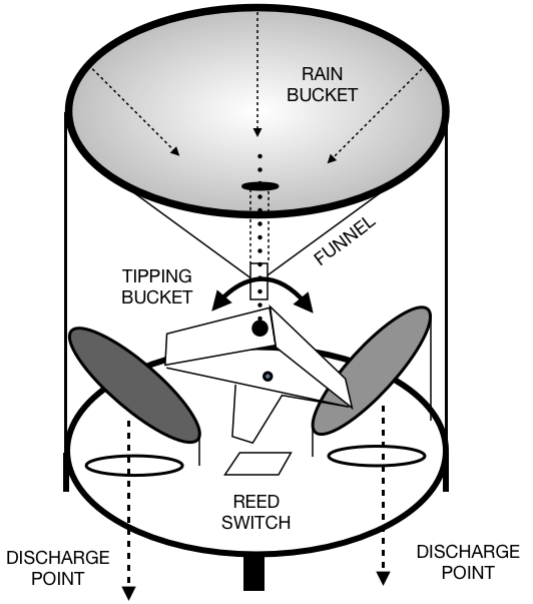
Precipitation

- Rain gauges are usually calibrated by measuring the mass of water passed through (tipping bucket rain gauge) or accumulated (weighing rain gauges).
- The principle of dynamic calibration system is to measure the decrease the mass over a given period of time and calculates rain intensity.
- They are therefore traceable to the kilogram and second.
- Weighing rain gauges are alternatively calibrated using calibrated masses.



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Wind speed / direction

- Wind tunnels (open, closed) that can cover the meteorological range are big and expensive.
- Reference instrument: Laser Doppler Anemometer – LDA or pitot tube.
- Typically a calibration of an anemometer is up to 50 m/s.
- Cup anemometer still widely in use, ultrasonic anemometers are takeing over.

Content

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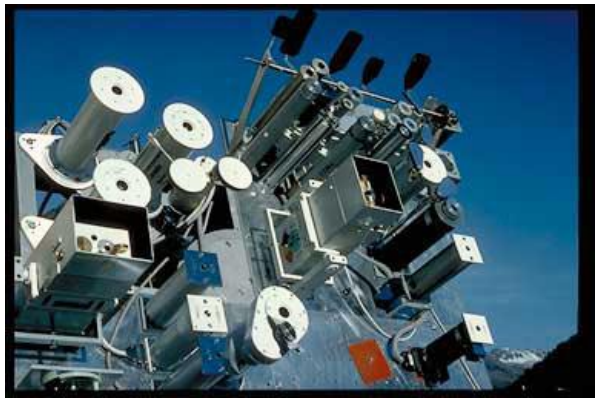
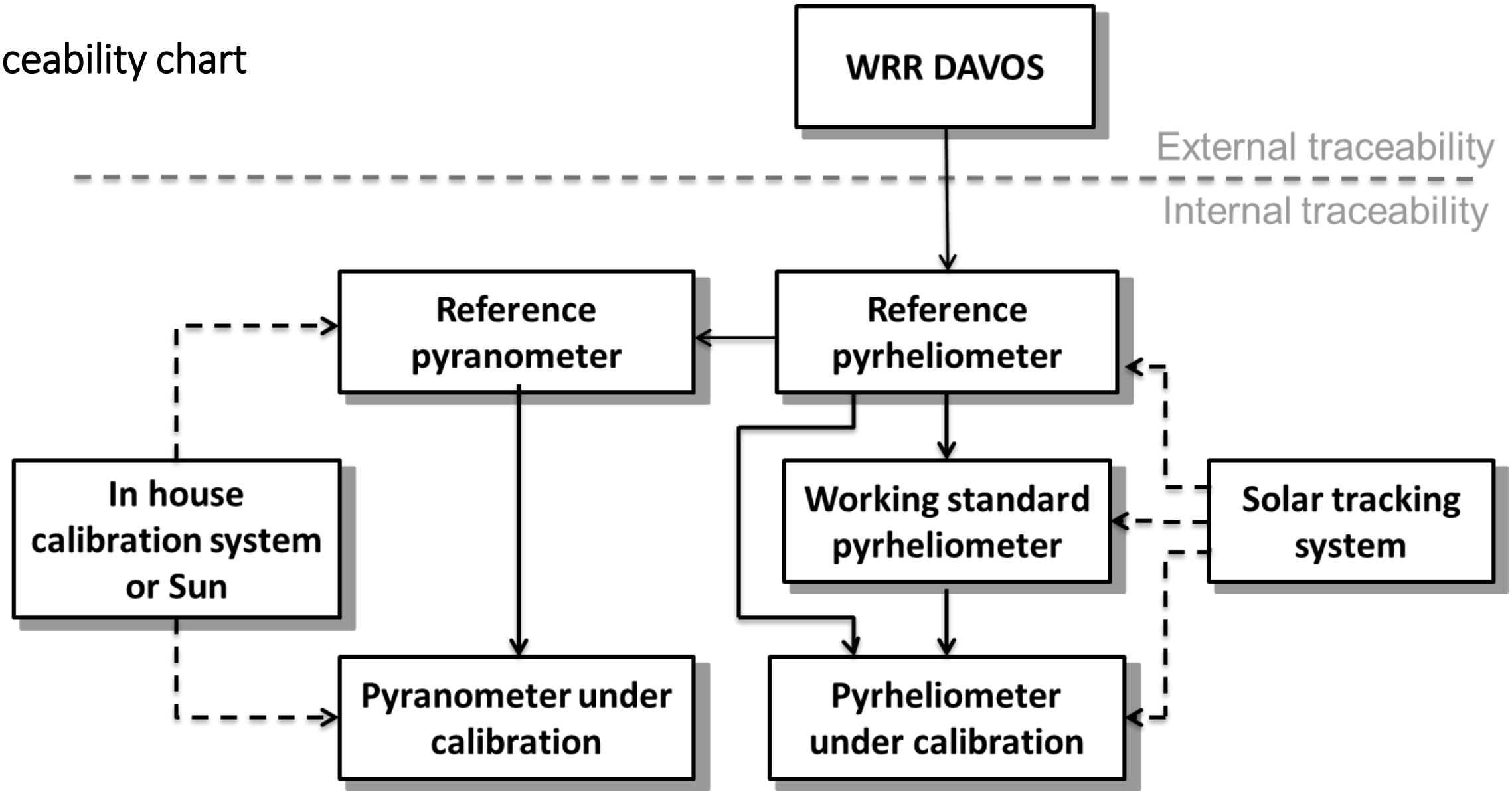
Solar radiation

- The World Standard Group instruments that represent the World Radiometric Reference (WRR) are hosted by the World Radiation Centre (Davos, Switzerland) and all reference instruments must be traceable to WRR.
- NMHS should use reference pyrheliometers, that are inter-compared at Davos (IPC is organized every 5 years). These are used to calibrate working standard pyrheliometers.
- Pyranometers can be calibrated in-house or using Sun as a light source.
- Several ways to disseminate traceability.



Solar radiation

Traceability chart



Quality system

- Calibration laboratory should implement requirements of ISO/IEC 17025 standard.
- **Written calibration procedures and work instructions (standard operation procedure – SOP) including calculation of measurement uncertainty.**
- This all takes time and is different for every laboratory

Most of all …

- You need good, motivated, competent staff
- Metrology is painstaking, often repetitive, sometimes boring
- Give added values to all measurements and products: data quality and reliability

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Thank you.

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