Infrastructure Commission (INFCOM)

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

Expert Team on Quality, Traceability and Calibration

Interlaboratory comparisons

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Proficiency testing / Interlaboratory comparison (ILC)

1. Terms and definitions
2. Purpose of interlaboratory comparison
3. Interlaboratory comparison protocol
4. Evaluation of the ILC results
5. Interlaboratory comparison example

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Various titles

- Interlaboratory proficiency study or test
- Round test, round robin test
- Test of qualification
- Certification study
- Interlaboratory validation

ISO/IEC 17043 Standard: "Conformity assessment — General requirements for the competence of proficiency testing providers"

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Proficiency testing - PT

Evaluation of participant performance against pre-established criteria by means of interlaboratory comparisons:

1. Quantitative schemes (objective is to quantify one or more measurands of the proficiency test item. Results of quantitative measurements are numeric)
2. Qualitative schemes (identify or describe one or more characteristics of the proficiency test item. Results of qualitative tests are descriptive)

A. Single occasion exercise (where proficiency test items are provided on a single occasion)
B. Continuous scheme (items are provided at regular intervals on a continuing basis (example 3 times per year))

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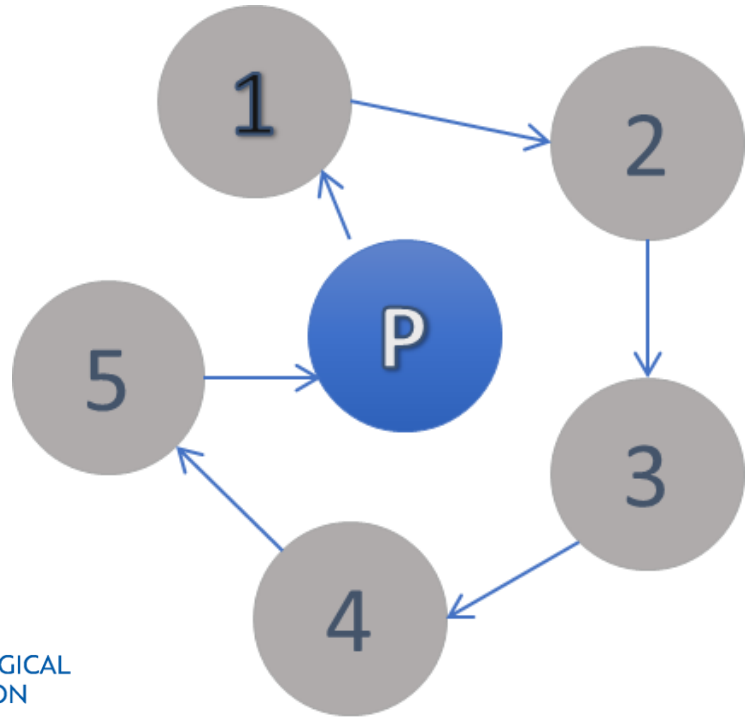
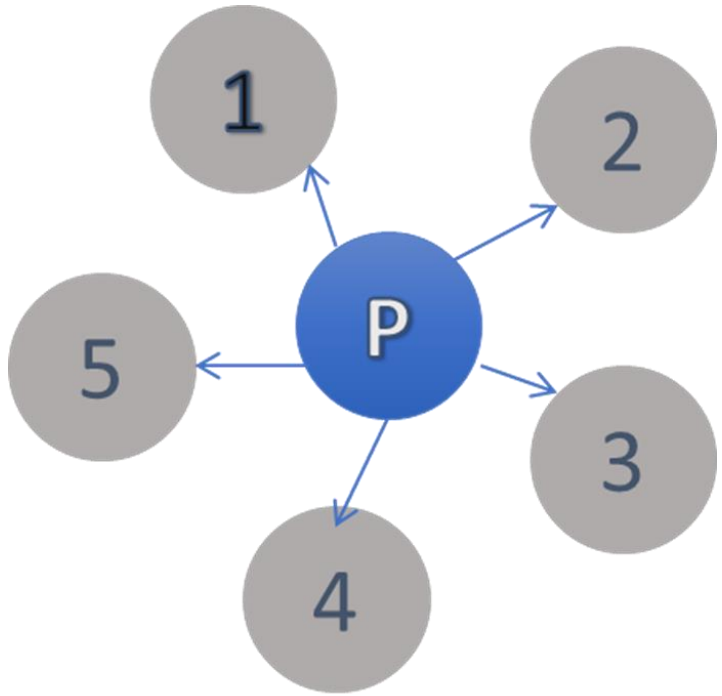
Proficiency testing - PT

a. Sequential scheme (one or more proficiency testing items are distributed sequentially for testing or measurement and returned to the proficiency testing provider at intervals for rechecking)

b. Simultaneous scheme (involve randomly selected sub-samples from a source of material being distributed simultaneously to participants for testing)





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Proficiency testing - PT

The term “Proficiency Testing” refers to activity undertaken by a laboratory in order to provide **objective evidence** that they are “**proficient”** or **“competent**” to perform measurements.

Calibration laboratories being more comfortable or familiar with the term, “**Inter-Laboratory Comparisons**” (ILC) and **testing laboratory** community being more familiar or comfortable with the term “**Proficiency Testing“** (PT).

Interlaboratory comparison – ILC

Definition (ISO/IEC 17043 Standard):

Organization, performance and evaluation of measurements or tests **on the same or similar items by two or more laboratories in accordance with predetermined conditions**.

- NOTE – In some circumstances, one of the laboratories involved in the intercomparison may be the laboratory which provided the assigned value for the test item

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Purpose of interlaboratory comparison

- **evaluation of the performance** of laboratories for specific tests or measurements and monitoring laboratories' continuing performance;
- **identification of problems in laboratories** and initiation of actions for improvement which, for example, may be related to inadequate test or measurement procedures, effectiveness of staff training and supervision, or calibration of equipment;
- establishment of the effectiveness and **comparability** of test or measurement methods;
- **provision of additional confidence** to laboratory customers;

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Purpose of interlaboratory comparison

- **identification** of interlaboratory differences;
- **education** of participating laboratories based on the outcomes of such comparisons;
- **validation** of uncertainty claims;
- **assignment of values to reference materials** and assessment of their suitability for use in specific test or measurement procedures;

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Purpose of interlaboratory comparison

- support for **statements of the equivalence** of measurements of National Metrological Institutes through "key comparisons" and supplementary comparisons conducted on behalf of the International Bureau of Weights and Measures (BIPM) and associated regional metrology organizations.

- Successful participation in an interlaboratory comparison is one of the necessary **requirements of the accreditation bodies** to obtain and maintain accreditation (ISO/IEC 17025:2017).

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What is an ILC?

Interlaboratory comparison serves as a tool for comparison of measurement results carried out **by accredited or non-accredited** calibration laboratories in the relevant field of measurement.

- ✓ILC represents very effective means to demonstrate technical competence of the participant

- ✘**It does not provide traceability for the participant's laboratory.**

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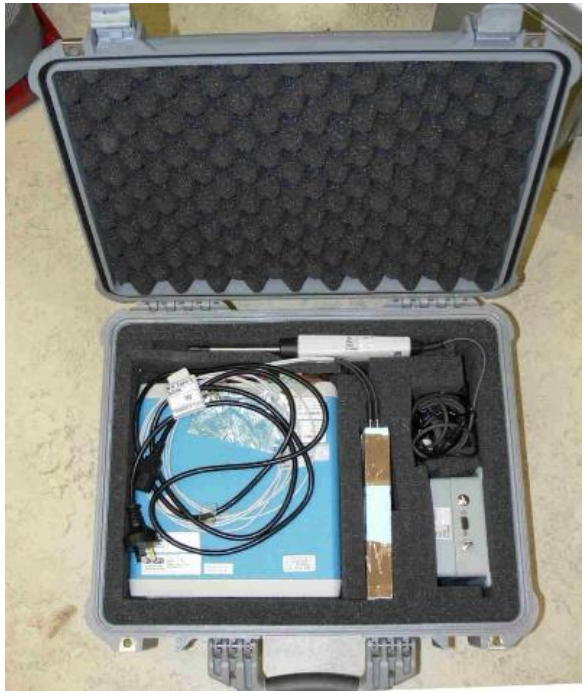
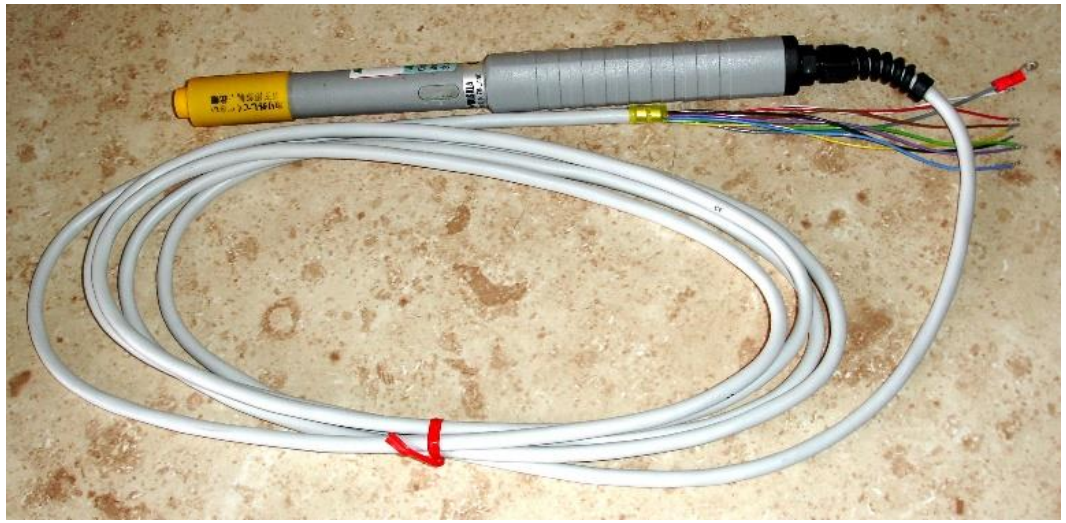
How a typical ILC is organized?

- Majority of ILCs in Meteo community were organized for basic meteorological parameters (T, RH, p).
- Set of transfer standards with appropriate metrological properties (ILC items) must be chosen.
- It is forbidden to make any adjustments of the items.





Reference laboratory

- Reference laboratory organizes ILC:
  - ILC coordination and documentation (ILC protocol)
  - Instructions on handling items, including safety
  - Packaging and transportation
  - Environmental conditions
  - Communication with participants
  - Confidentiality of records, if agreed among participants
  - Data analysis and records, evaluation of the results
- Reference laboratory provides **ILC protocol** carrying information on purpose of the ILC, data acquisition, calibration points, transportation requirements, schedule and reporting of the results.
- Participants normally perform measurements in accordance with their **routine procedures**.

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Reference value

ILC consists of **comparison of measurement results** of a laboratory and a **reference value** defined by reference laboratory/laboratories, which is the highest authority for the particular measurements:

- Reference value could be defined by **reference laboratory.**
- Reference value could be defined by a **group of participating laboratories**. The assigned value is calculated as mean of reference laboratories. The uncertainty of the assigned value is calculated as uncertainty of mean, with uncertainties of reference laboratories at each calibration point.

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Evaluation of the results

Number of methods for evaluation of ILC results:

Z-score: $$Z = \frac{x_{lab} - x_{ref}}{\sigma_p} \qquad Z \in < -2;2 >$$

zeta-score: $$\zeta = \frac{x_{lab} - x_{ref}}{\sqrt{u_{lab}^2 + u_{ref}^2}} \qquad zeta \in < -2;2 >$$

En-score: $$En = \frac{x_{lab} - x_{ref}}{\sqrt{U_{lab}^2 + U_{ref}^2}} \qquad En \in < -1;1 >$$

X_{lab} - value reported by laboratory
X_{ref} - reference value
σ_p - target value of standard deviation
U_{lab} - expanded uncertainty of laboratory
U_{ref} - expanded uncertainty of assigned value

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Normalised error - En

The evaluation of the measurement results is made on the basis of the normalized error En. The normalized error En is given by the formula:

$$En = \frac{x_{lab} - x_{ref}}{\sqrt{U_{lab}^2 + U_{ref}^2}}$$

where:

- X_{lab} - value measured by the participating laboratory,
- X_{ref} - reference value,
- U_{lab} - expanded (k=2) uncertainty of the value measured by the participating laboratory,
- U_{ref} - expanded (k=2) uncertainty of the reference value.

Criteria for performance evaluation is:

If $|En| \leq 1$, the measurement result is assessed as **satisfactory**,

if $|En| > 1$, the measurement result is assessed as **unsatisfactory.**

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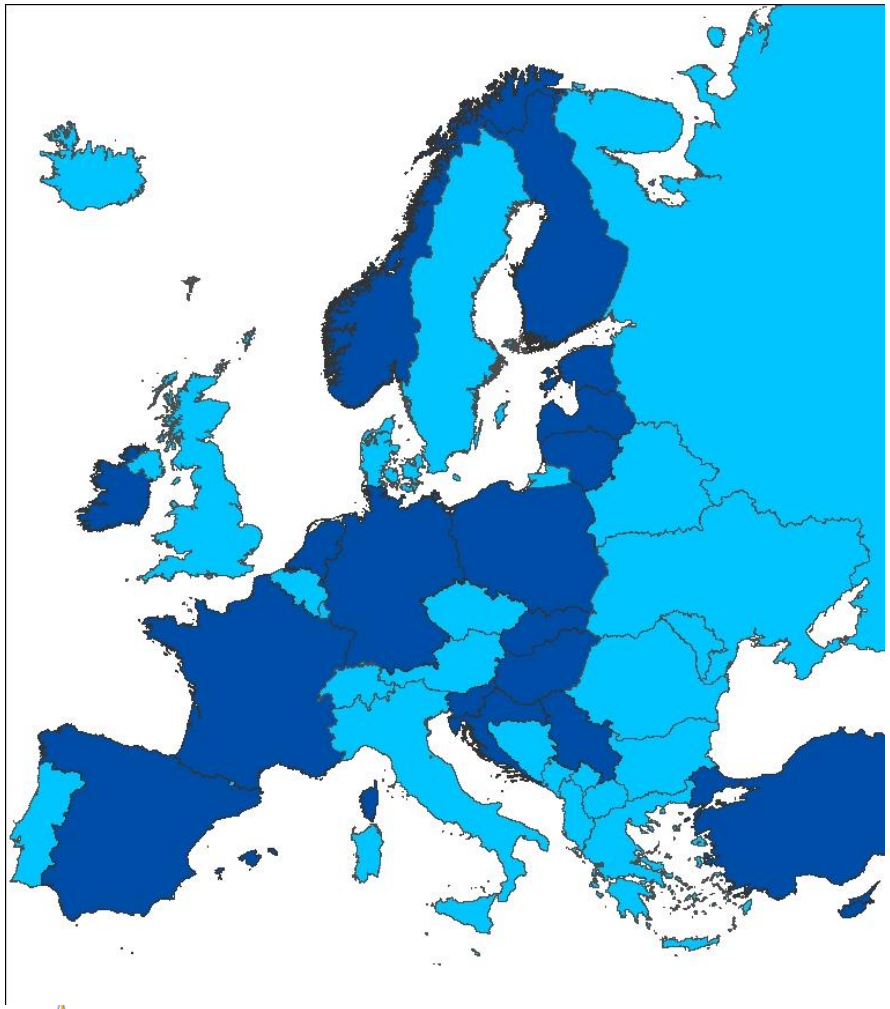
Example: ILC in RA-VI : MM-ILC-2015-THP (2016)



18 NMHSs participated in ILC: Croatia, Cyprus, Estonia, Finland, France, Germany (2), Hungary, Ireland, Latvia, Lithuania, Netherlands, Poland, Serbia, Slovakia, Slovenia, Spain and Türkiye.

Four reference laboratories (Meteo France, Slovakian Hydrometeorological Institute and Slovenian Environment Agency) and UL-FE/LMK Ljubljana also accredited for implementation of interlaboratory comparisons by ISO/IEC 17043:2010.

The **ILC kits consisted** of two identical sets of transfer standards: capacitive hygrometers HMP155, barometers PTB220 and four wired Pt-100 resistance thermometers ELPRO with display Agilent/HP 34420A.

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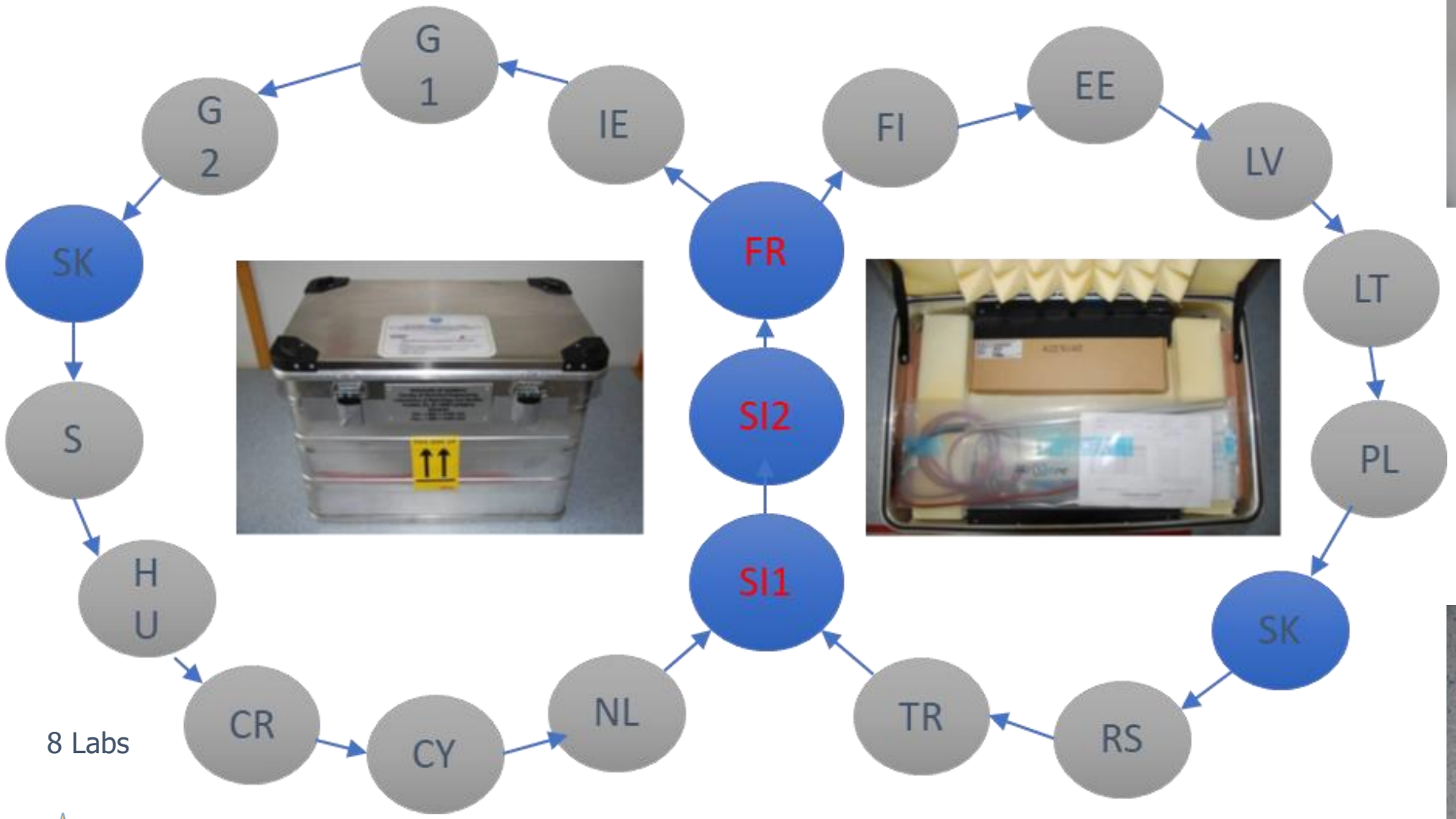

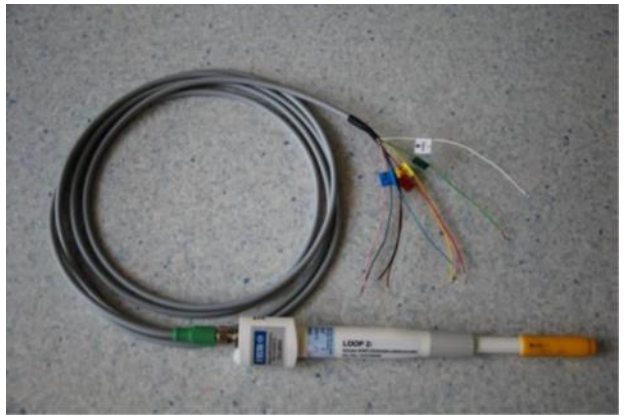

8 Labs

7 Labs

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Calibration points

Temperature (tolerances ±0.2 °C):

-30	-20	-10	0	10	20	30	40	°C

Relative humidity (tolerances ±3 % RH):

10	20	35	55	75	90	95	% RH

Air pressure (tolerances ±20 hPa):

800	850	900	950	1000	1050	1100	hPa

Environmental conditions

Calibration is carried out at an ambient temperature of (20 ± 5) °C and relative humidity of (30 ÷ 60) % RH

Coding

Final results of the participants are anonymous (each laboratory with different code).

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Assigned value and its uncertainty

$$\hat{a}_1 = \frac{\sum_{i=1}^{n} \frac{y_i}{u^2(y_i)}}{\sum_{i=1}^{n} \frac{1}{u^2(y_i)}}$$

$$u^2(\hat{a}_1) = \frac{1}{\sum_{i=1}^{n} \frac{1}{u^2(y_i)}} + \left(\frac{Max(y_i - \hat{a}_1) - Min(y_i - \hat{a}_1)}{\sqrt{3}} \right)^2$$

$\hat{a}_1$ - comparison assigned value,

y_i - measurement values of reference laboratories,

$u(y_i)$ - uncertainty of measurement values,

$u(\hat{a}_1)$ - uncertainty of assigned value.

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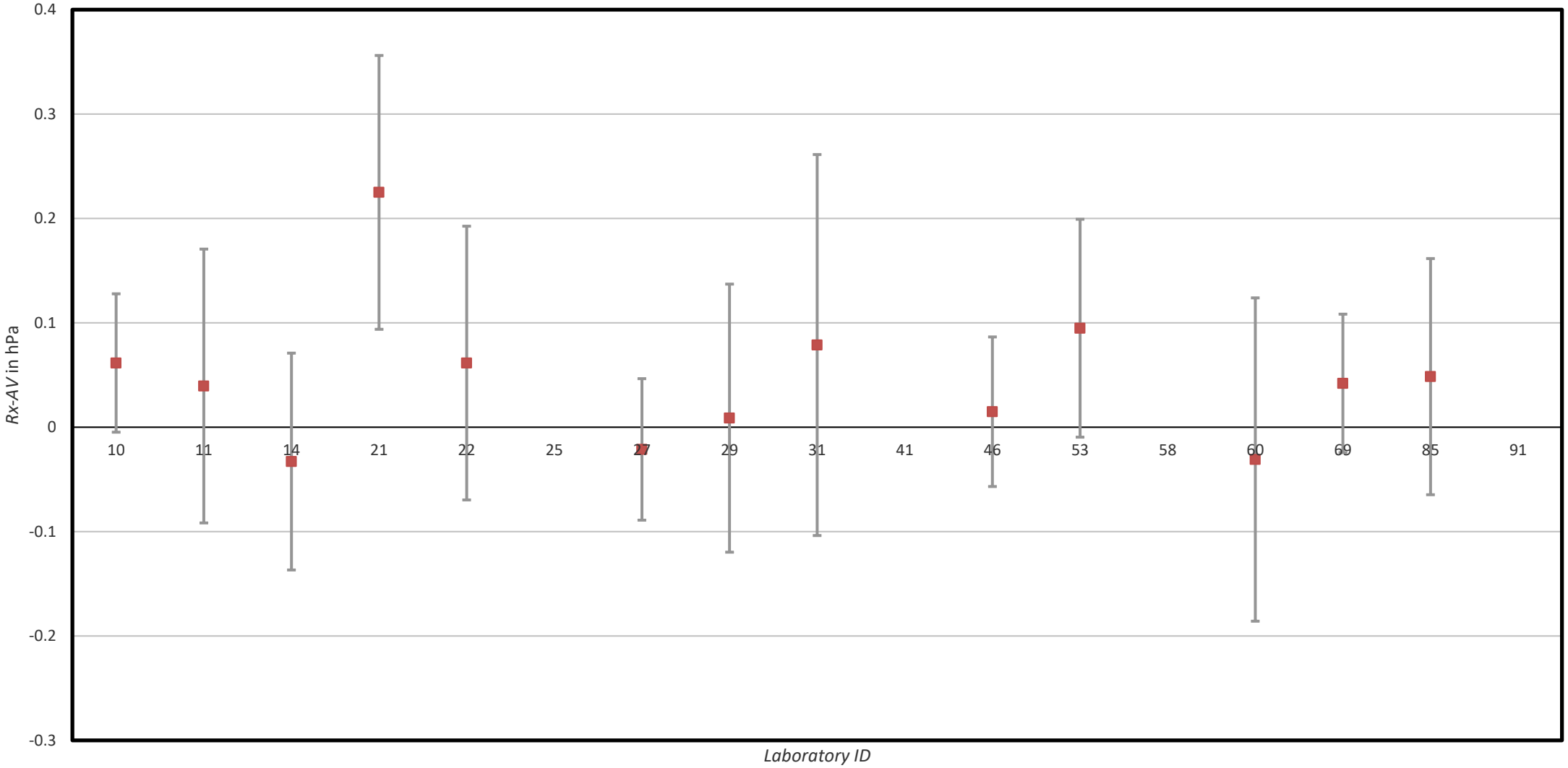
PRESSURE: Rx-AV, including uncertainties at 1100 hPa



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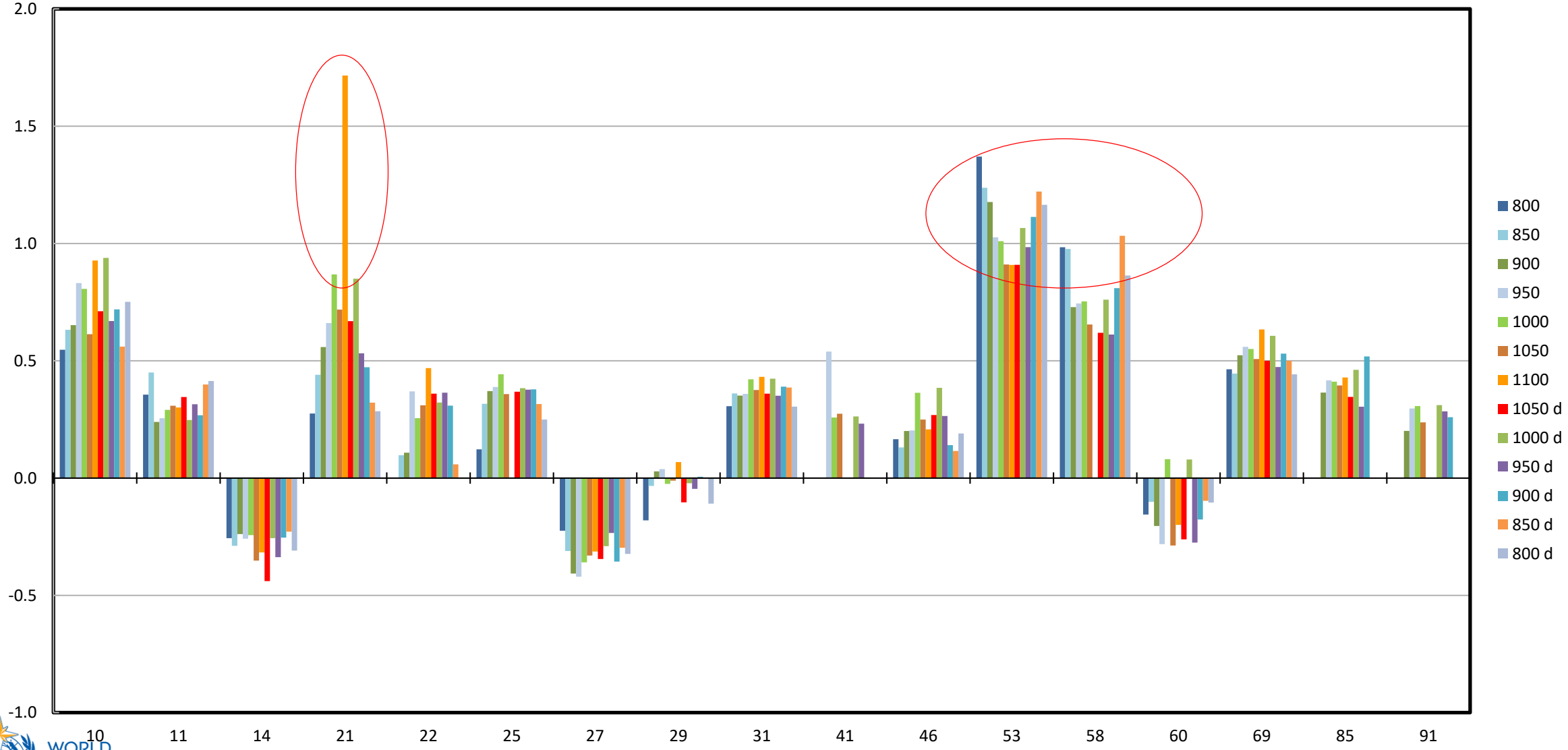
Summary of *En* values for pressure calibrations



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Only 52 results (4%) of 1171 have |En| >1

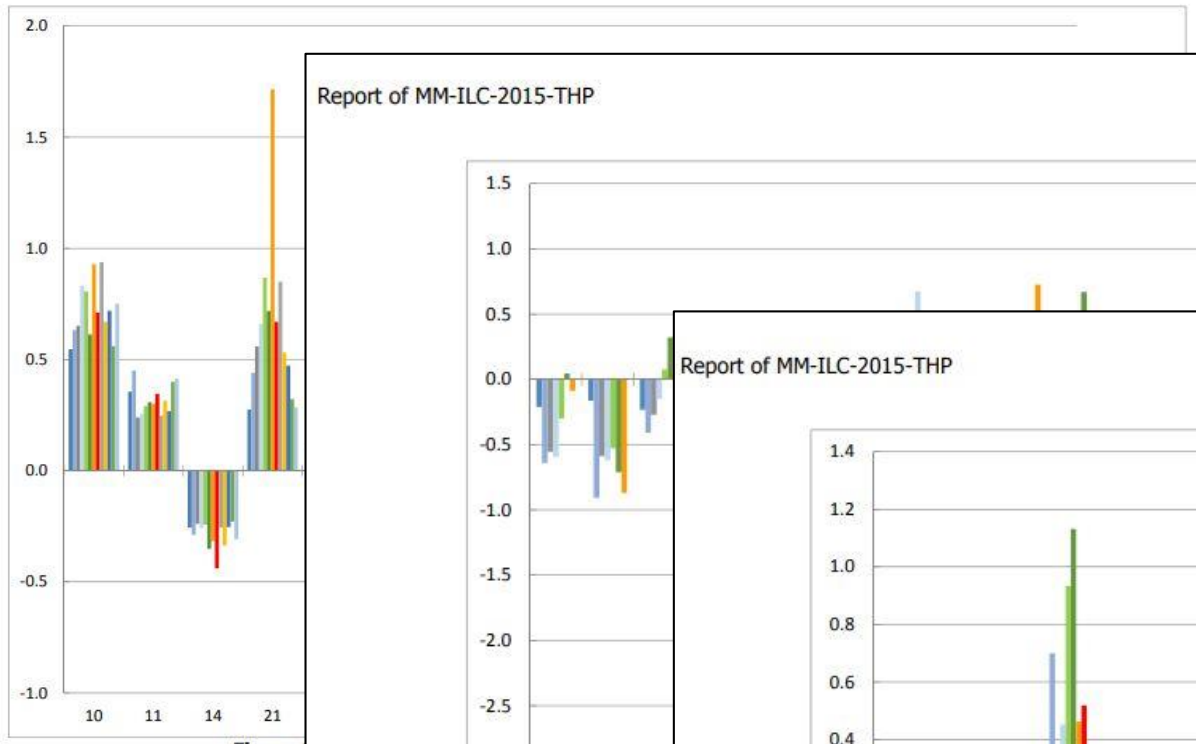

Figure 1

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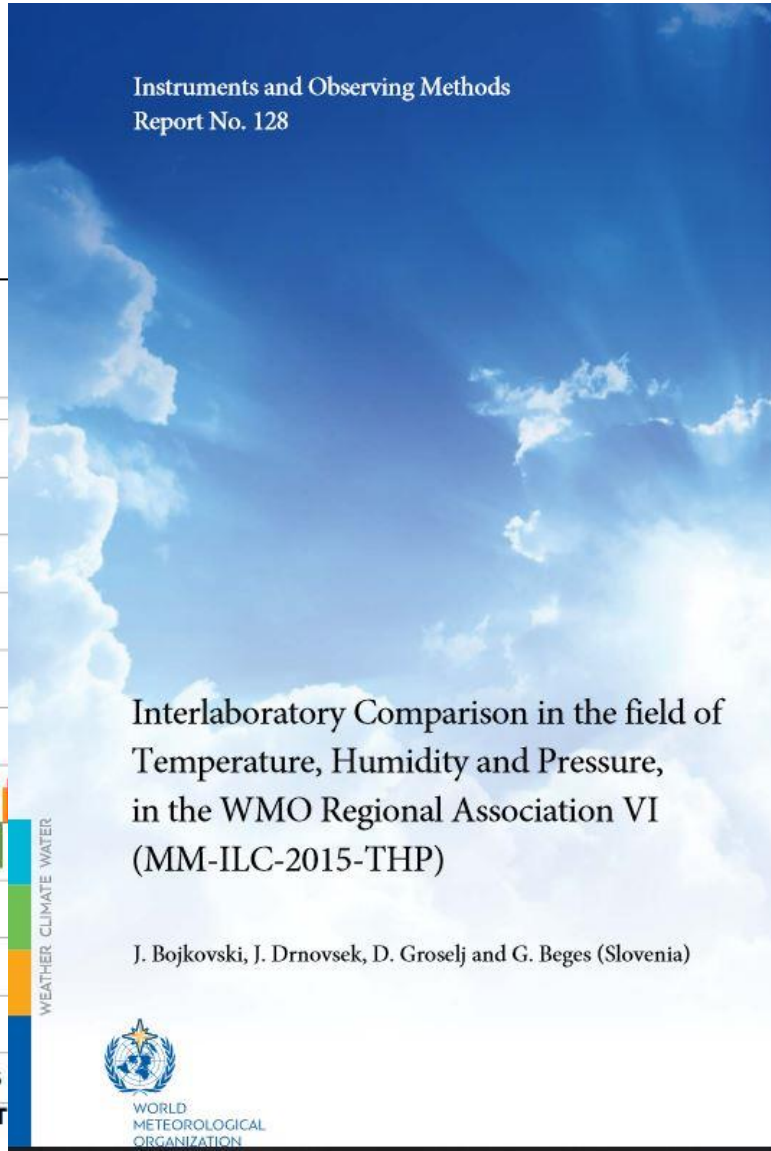
Figure 32: Summary of *En* values for all temperature calibrations for PT



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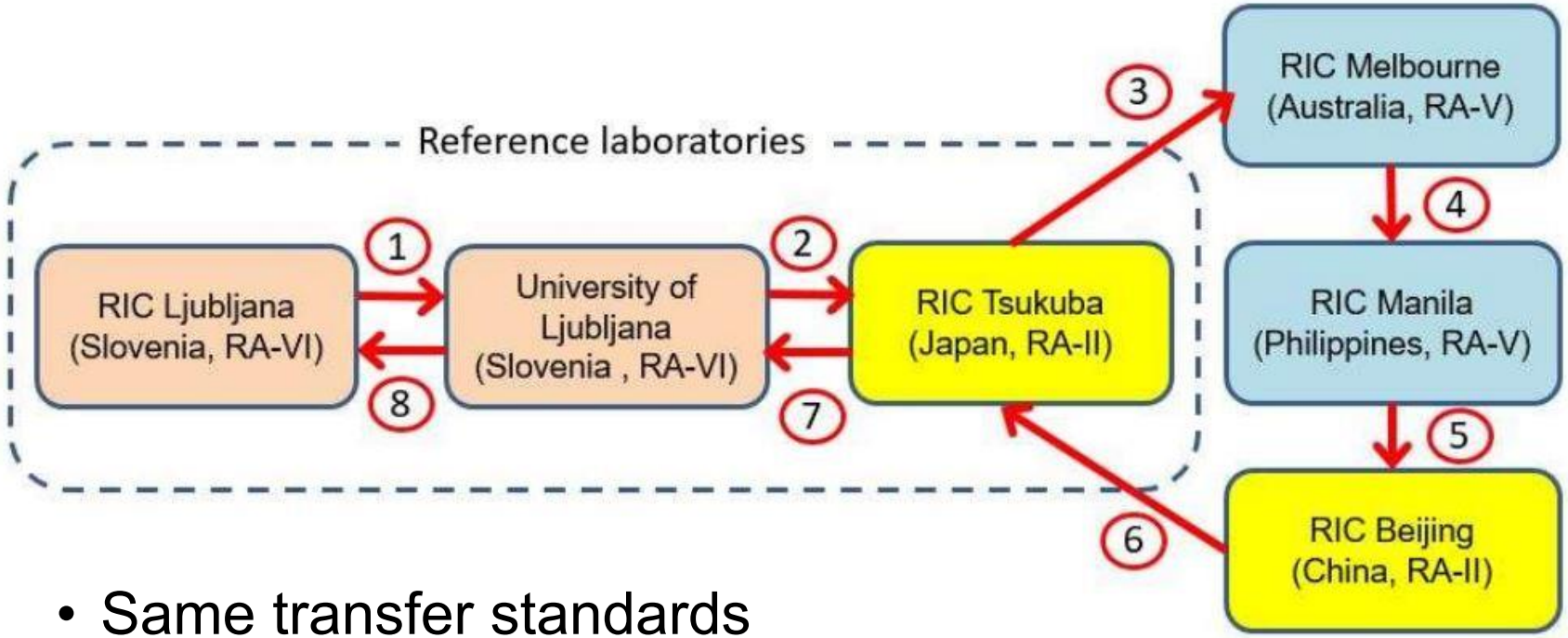
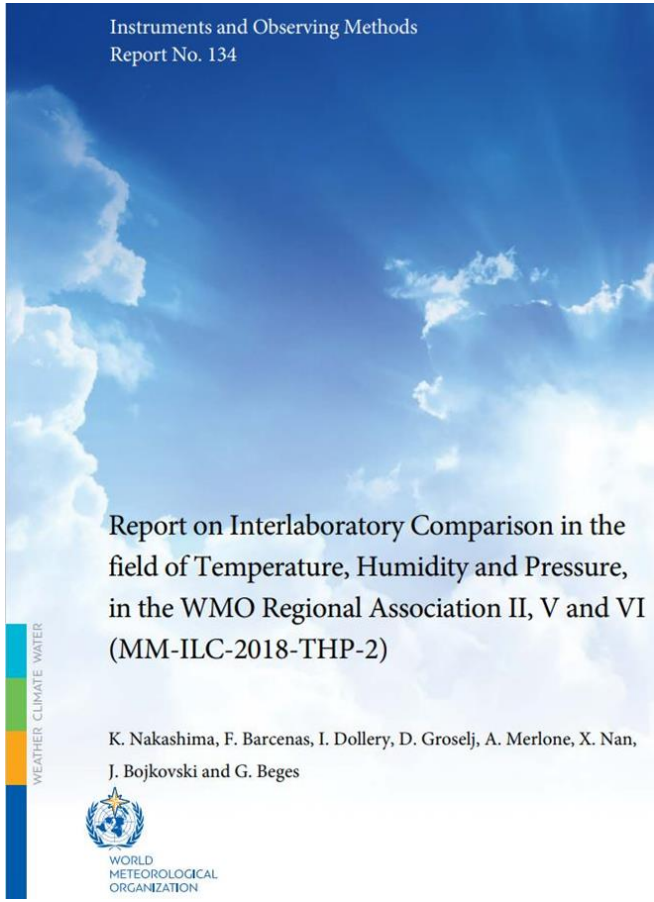
Interlaboratory comparison: MM-ILC-2018-THP-2 (2021)





- Same transfer standards
- Similar ILC protocol
- Same data evaluation
- Same linkage laboratories

Only 32 results (6%) of 538 have $|E_n| > 1$

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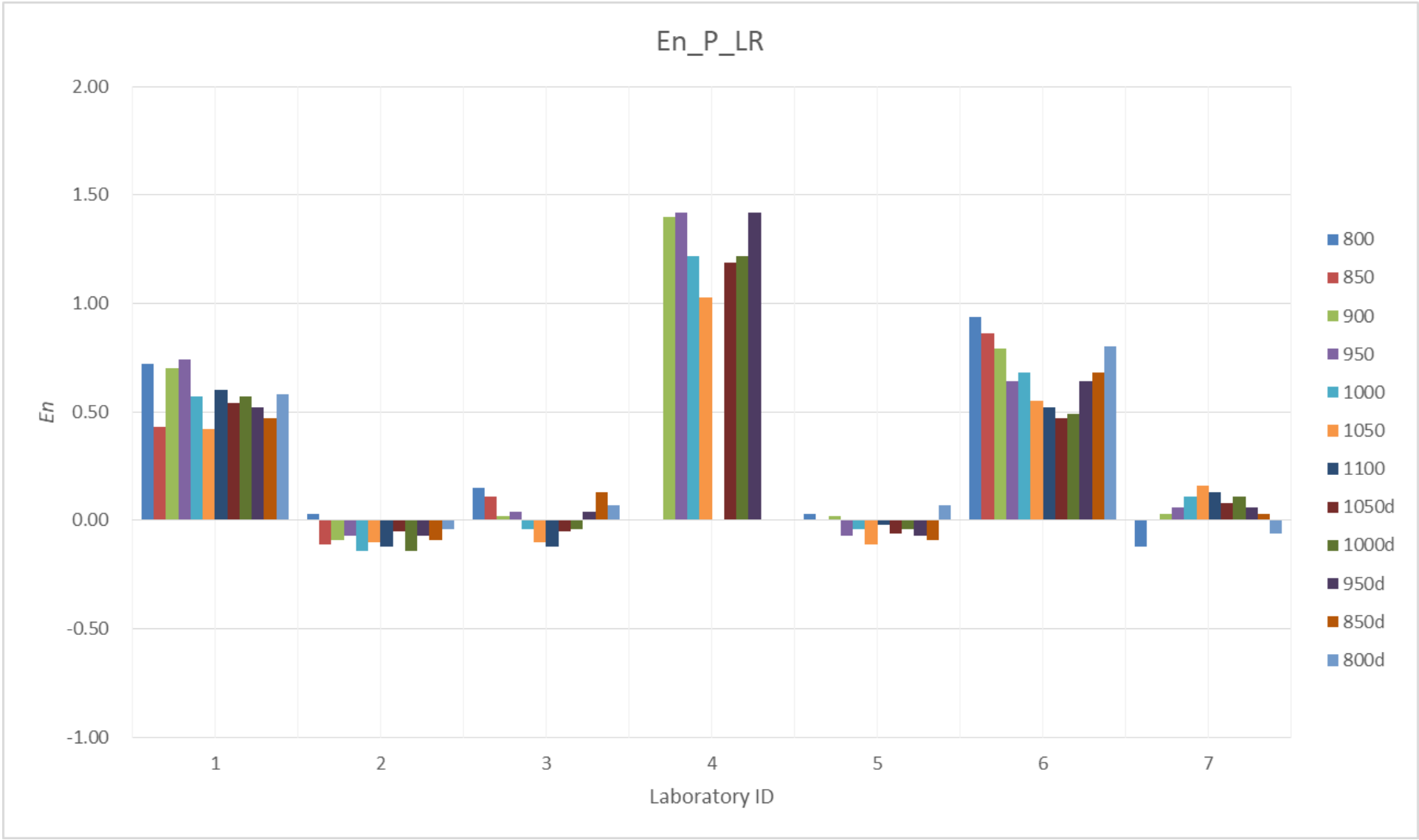
Summary of *En* values for pressure calibrations



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Thank you.

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