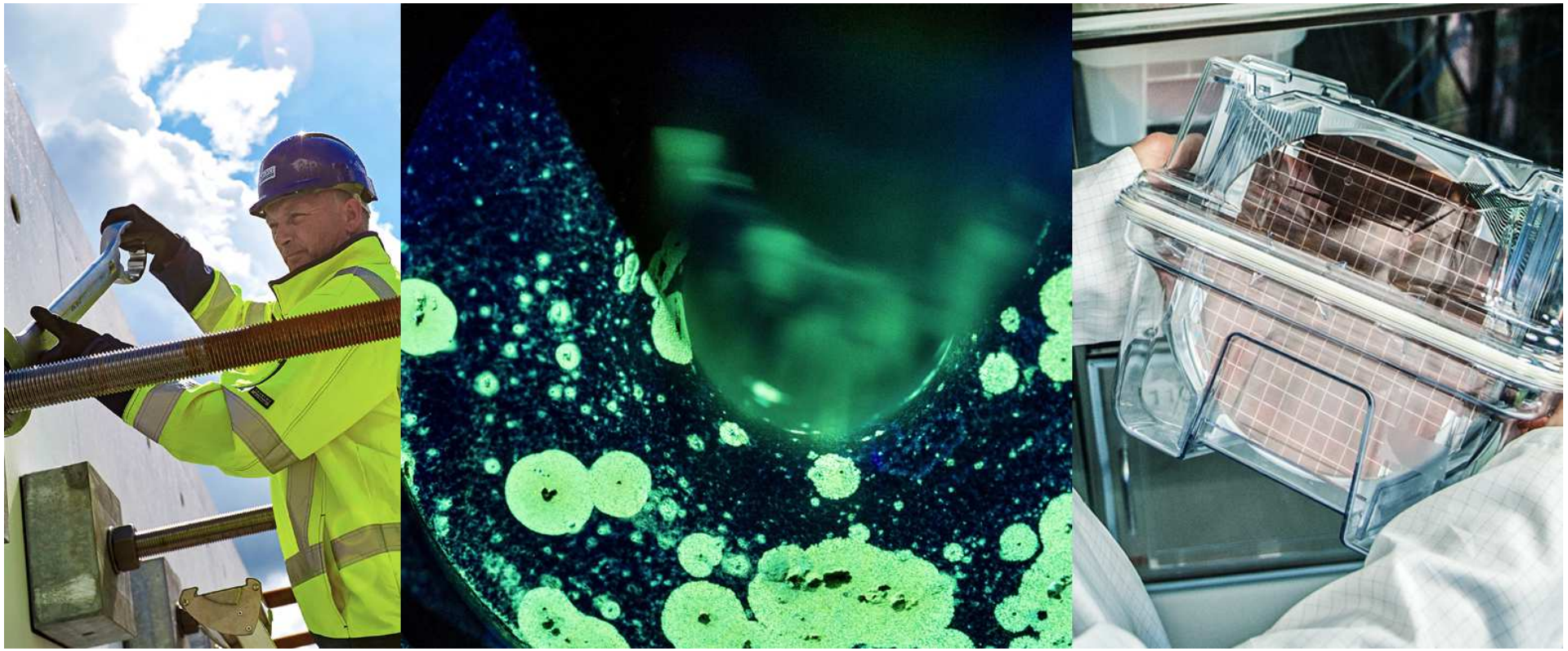

# Piston Prover intercomparison within EuReGa

## Participants, VSL, PTB and FORCE

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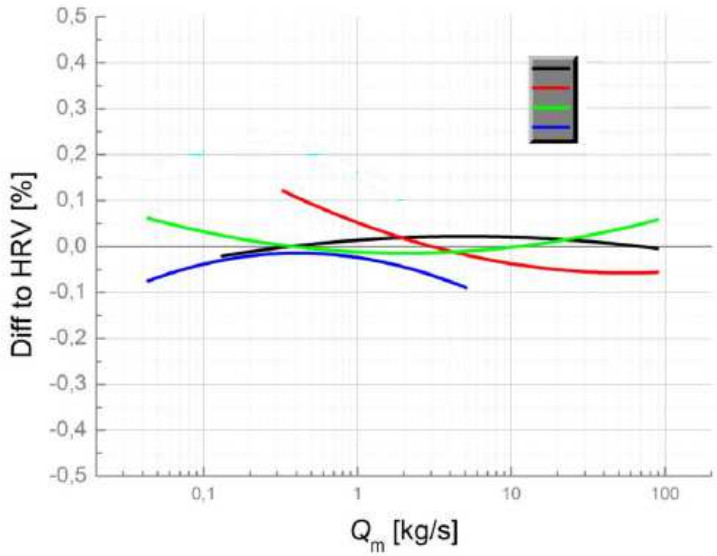
# About EuReGa

- **Eu**ropean **Re**ference for **Ga**s metering
- Four members of EuReGa
  - PTB, LNE-LADG, VSL and FORCE Technology
- Harmonization every three years
  - Each participant has traceability to primary calibration systems
  - Participants use reference meters to calibrate transfer standards
  - Range 8-50 barA and 25-6500 $m^3/h$
  - Uncertainty in the area of 0.13-0.20%



# Introduction to the intercomparison

- Intercomparison performed in 2018 and 2019.
- Part of Euramet project 1301, EuReGa-1
- Participants were VSL, PTB and FORCE
  - LNE-LADG did not participate as their primary is a PVTt
  - LNE-LADG and PTB along with NIM and NIST however did a succesful intercomparison of primary standards in 2015.
- Low uncertainty reported for all participants

# Why this intercomparison?

- Support current CMC claims of the participants
  - Second usage for FORCE, support of a new CMC in the BIPM database
- Further strengthen the European harmonized reference value
- Better understand the difference between the EuReGa members at the lowest possible uncertainty

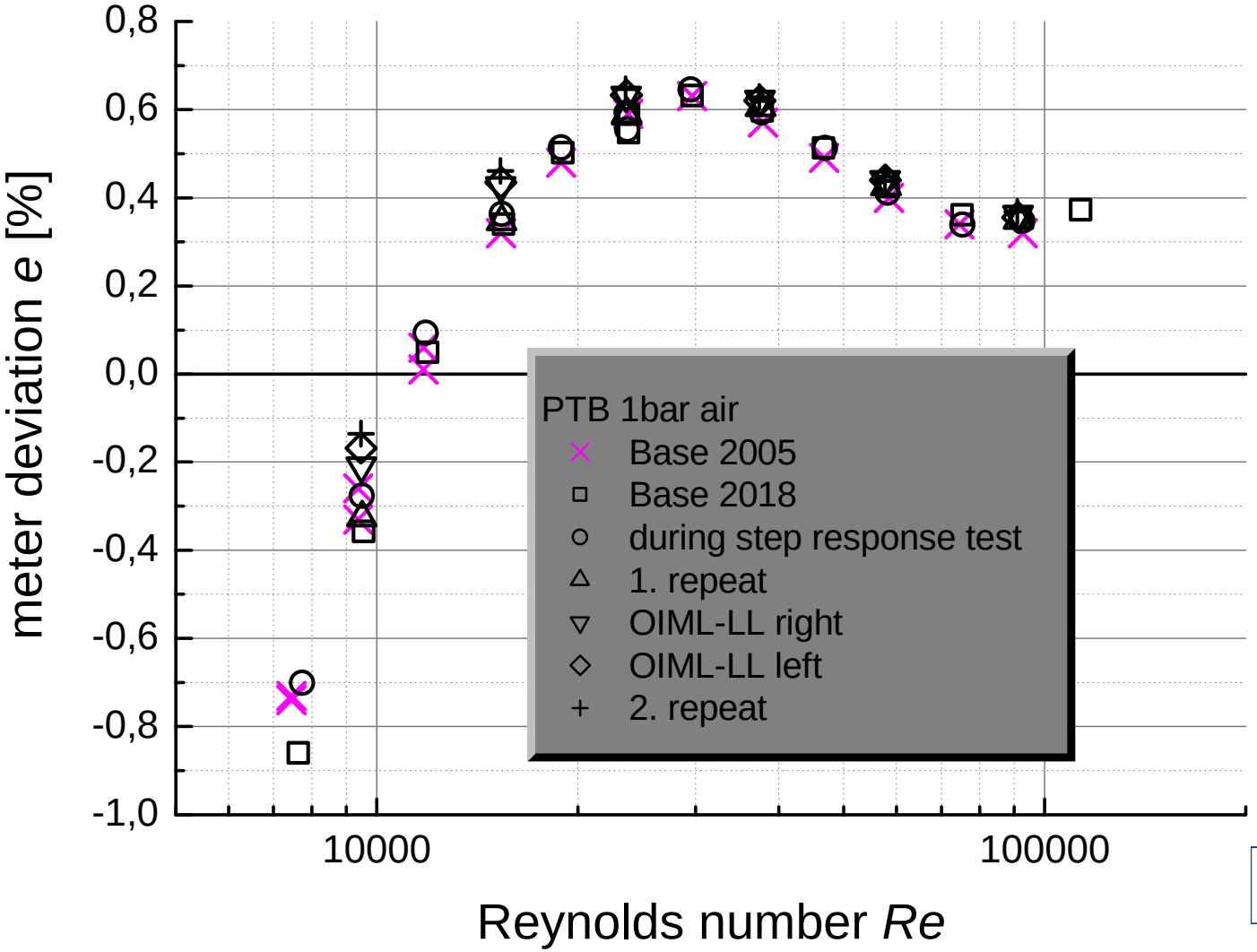
# About the Piston Provers

| Institute | VSL | PTB | FORCE |
|---|---|---|---|
| **Primary device** | 24” Gas Oil Piston Prover (GOPP) | 10” Piston Prover (HPPP) | 26” Twin Piston Prover |
| **Piston** | Passive | Passive | Active |
| **Nominal diameter** | 600 mm | 250 mm | 660 mm |
| **Absolute operating pressure** | 1 – 62 bar | 8-51 bar | 1-66 bar |
| **Piston stroke / effective stroke** | 12 m / 6.5 m | 6 m / 3 m | 2.8 m / 0.6-2.7 m |
| **Flowrate range** | 3 – 230 $m^3/h$ | 3 – 480 $m^3/h$ | 2 – 400 $m^3/h$ |
| **Maximum piston speed** | 0.25 m/s | 3 m/s | 0.17 m/s |
| **CMC** | 0.070 – 0.086% | 0.065 % | 0.080 % |

# Test Protocol

- Two G250 meter packages designated EuReGa DN100 M1 and M2
  - Meters normally used for the EuReGa intercomparison every three years.
  - Fixed upstream flow conditioner, upstream spool, meter, downstream spool with thermowell.
- Flowrates 25, 40, 65, 100, 160, 250 and 400 $m^3/h$
  - VSL calibrate up to their Piston Prover's maximum flow and calibrated only one of the meters, M2
- Pressures 8, 20 and 50 bar absolute pressure with natural gas
- Average error was calculated for each flowrate based on four to five successive measurements.
- Calibration sequence
  - FORCE in March-April 2018
  - PTB in May-June 2018
  - VSL in January 2019

# Meter information

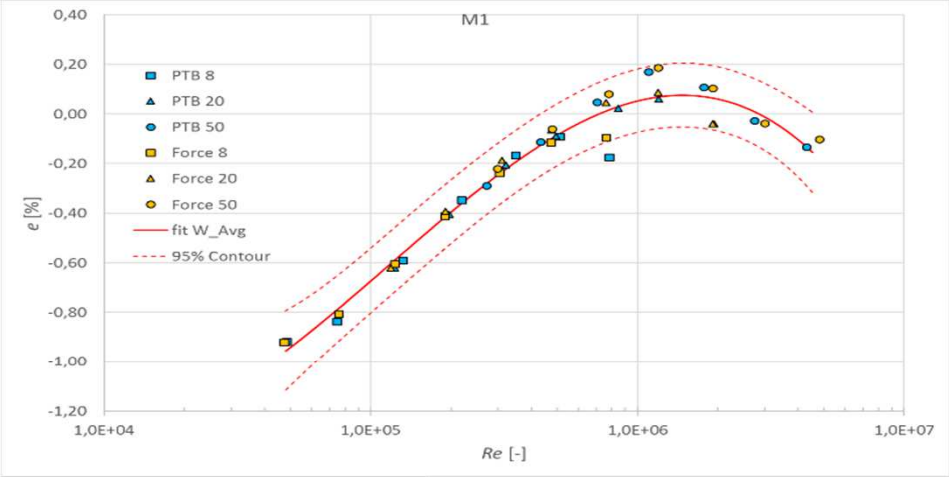


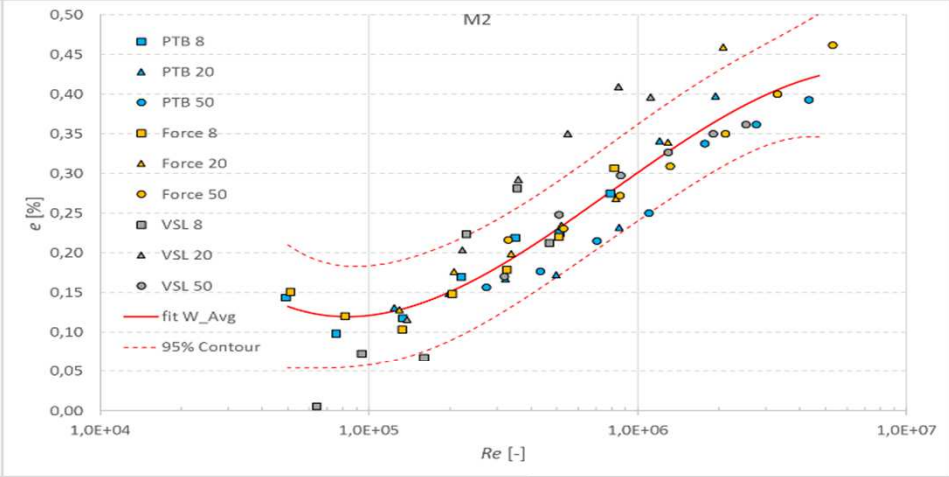
# Picture of the meter packages

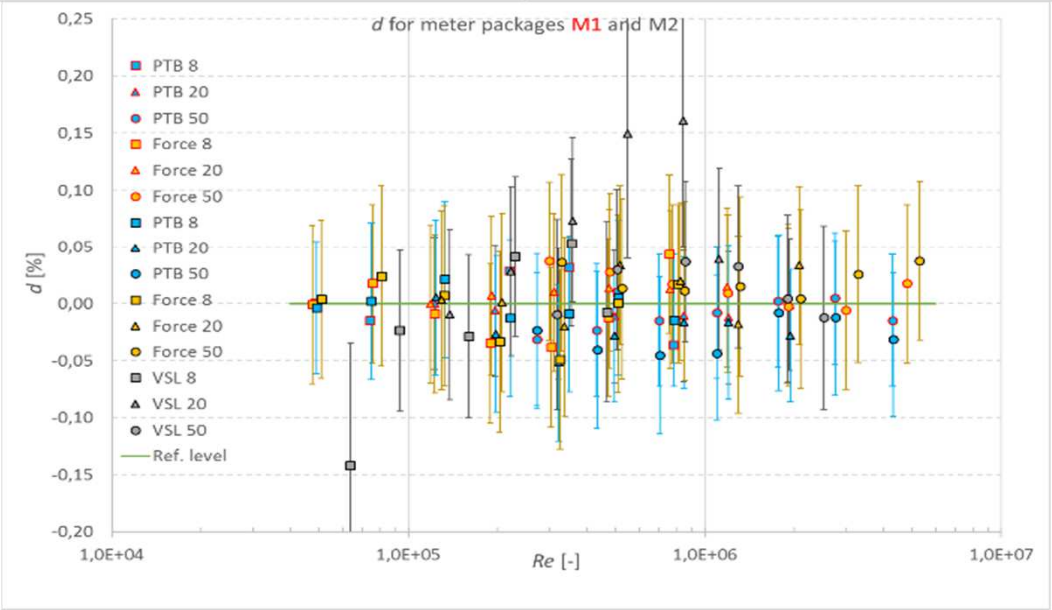
# Methodology, Data analysis

- Performed according to Cox, M. G. (2002). The evaluation of key comparison data, Metrologia, Vol. 39, No. 6, 589-595
- A comparison reference value (CRV) weighted average is calculated based on results at the nominal flowrates
- A chi-squared test for consistency used to investigate observed differences
  - Based on this, three datapoints were excluded from calculation of the weighted average
- A deviation d was calculated based on the participants difference to the weighted average
- $E_N$ values were finally calculated based on the deviatons and their uncertainty

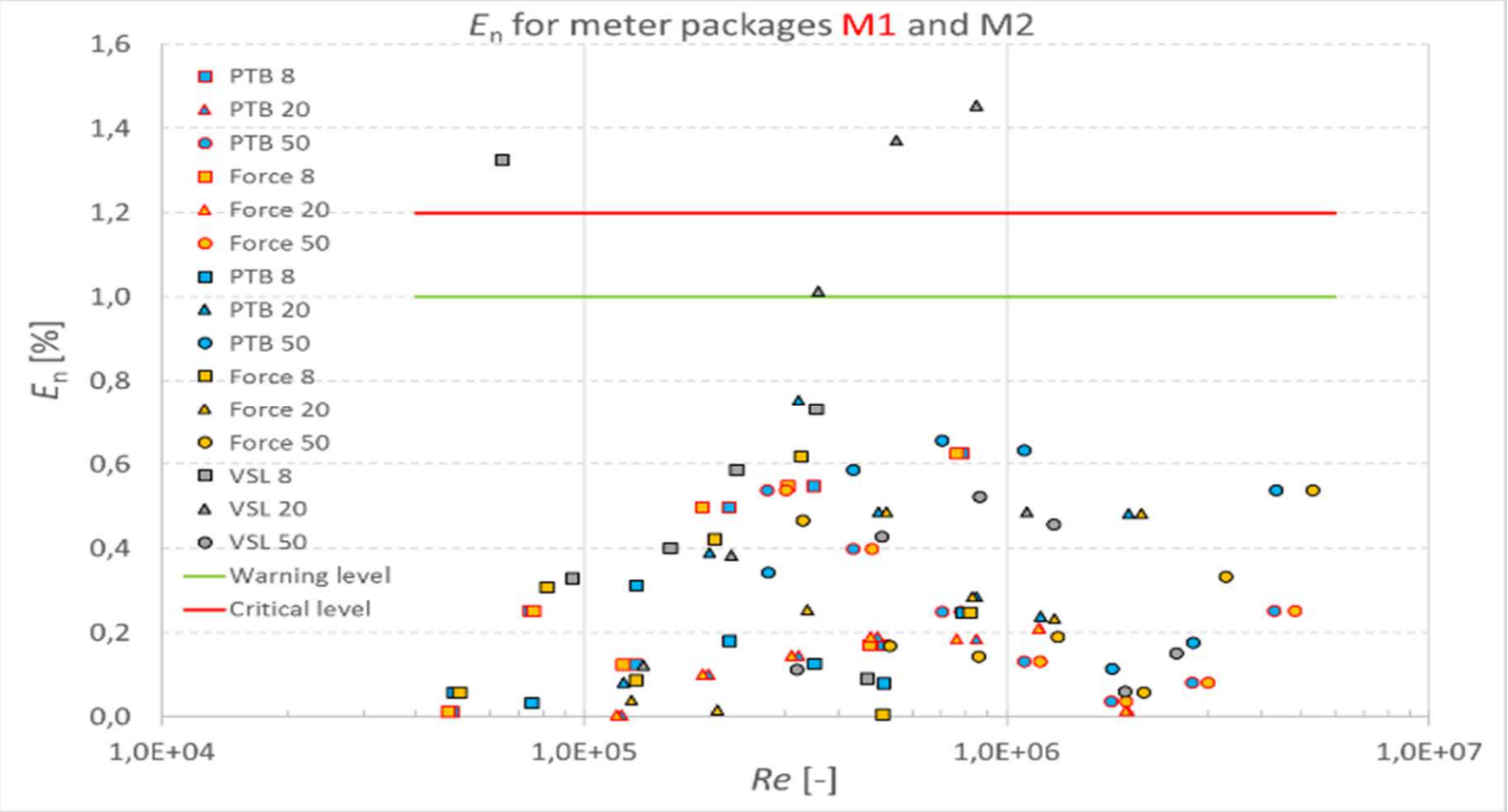
# Calibration results



# Results of the intercomparison

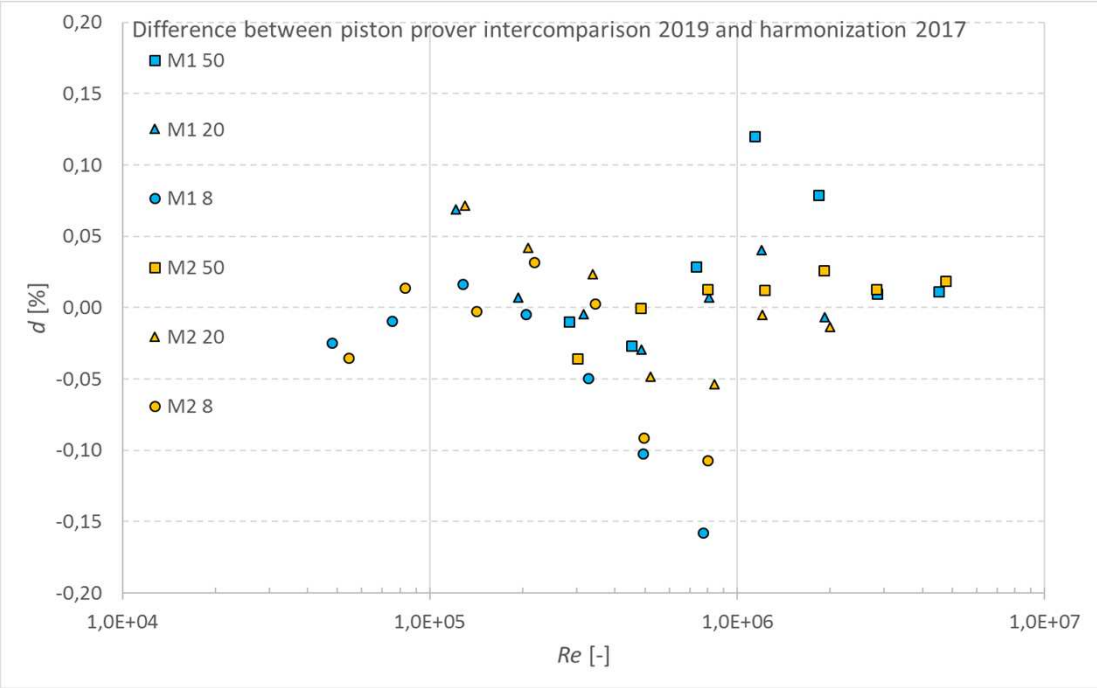



- Three points were excluded based on the chi-squared test
- 96% of En values below 1

# Comparison with historic results

- CRV 2019 compared against CRV for the same meters used in 2017

- Average difference: -0.004%
- 50% of |differences|<0.024%



# Conclusion

- Results are compliant with 96% of the EN values lower than 1
  - Bilateral intercomparison planned to investigate the few inconsistencies
- Results also match historic results of the meters used in the intercomparison

# What can the results be used for

- Tells us that not only are the members of EuReGa equivalent with reference meters, but also at the very start of the traceability lines and very low uncertainty.
- To support our CMC's
  - A new CMC for FORCE is currently in the review process
- Can help us understand where in our traceability lines if anywhere do our results begin to diverge and thus can help us develop our traceability systems
- Strengthens the confidence in the European harmonized reference value

# Thank you for your attention.

# Questions?

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