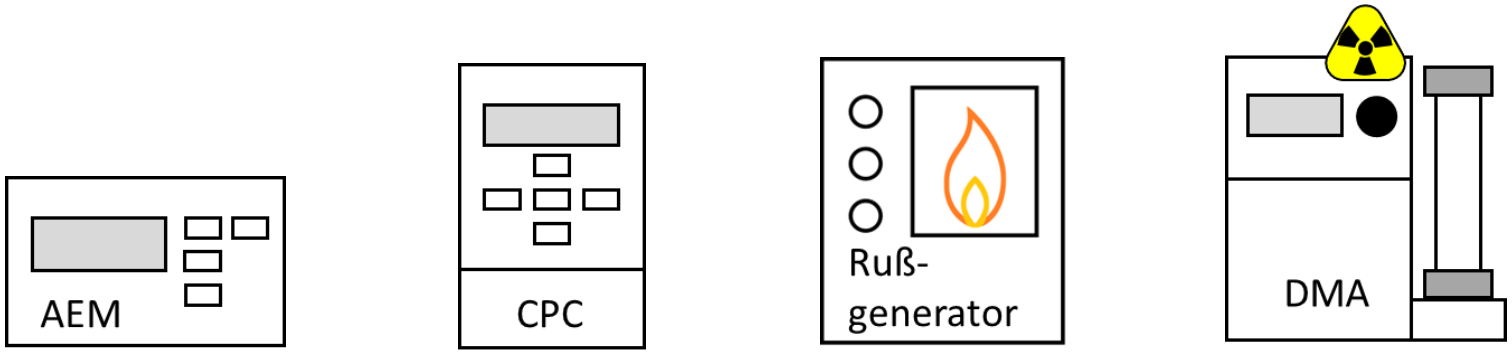
# Concept for an automotive 10nm calibration standard

50th PMP Meeting
2019-04-03
Alexander Terres



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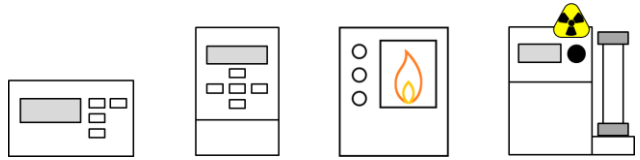
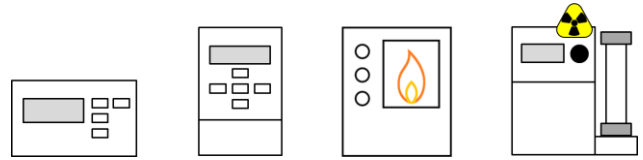
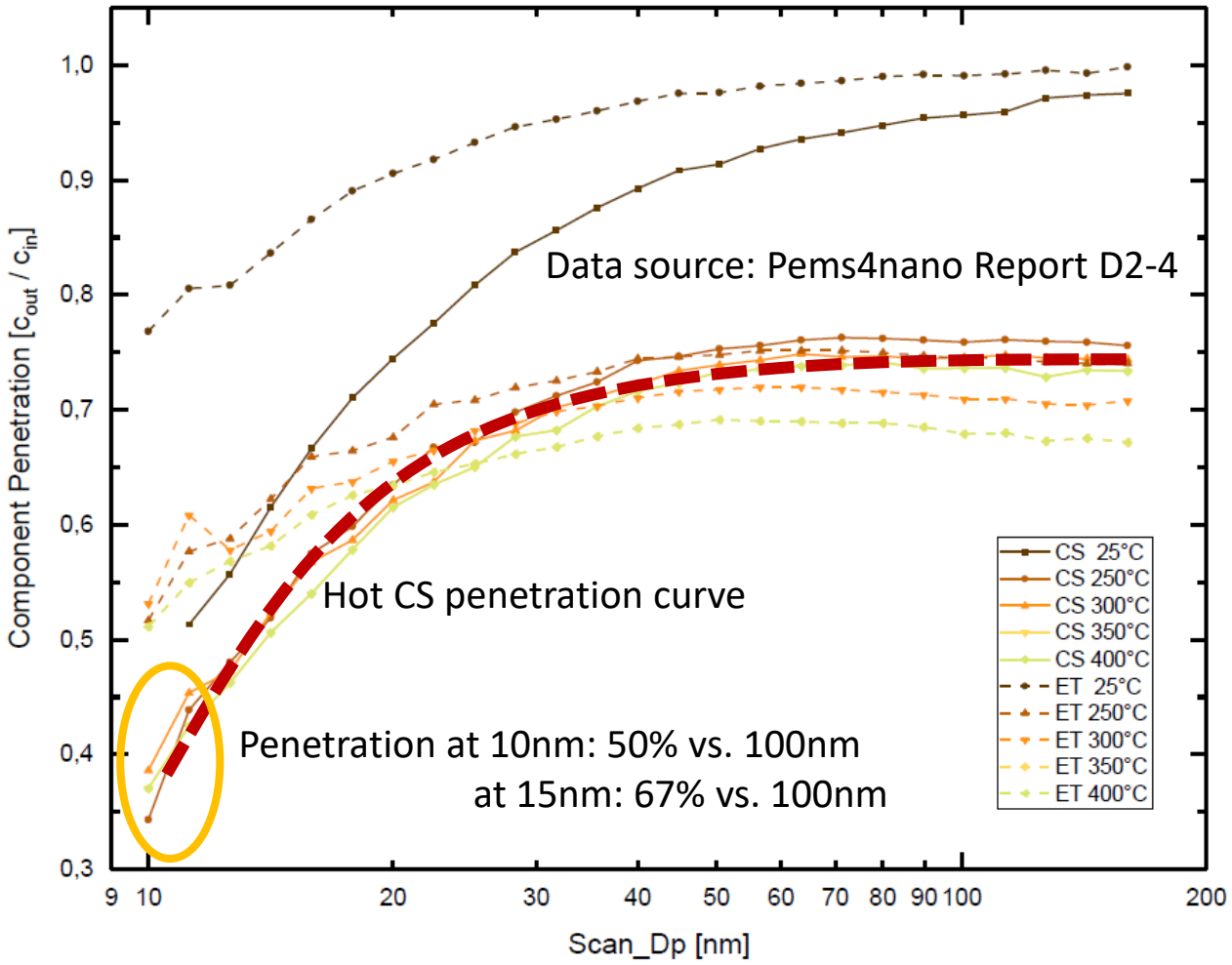


- 10nm exhaust PN counter instrument definition
- Calibration concept
- Calibration aerosol
- Calibration setup
- Discussion of advantages/disadvantages

# EXHAUST PN COUNTER INSTRUMENT DEFINITION



- Performance of exhaust PN counter is dominated by **Catalytic Stripper penetration**
- Steep drop of system performance at 10/15nm **independent of CPC** counting efficiency
- Main target of calibration must be **CS penetration**
  → Thermally stable standard aerosol
- Data/knowledge of CS penetration in this application is **insufficient**



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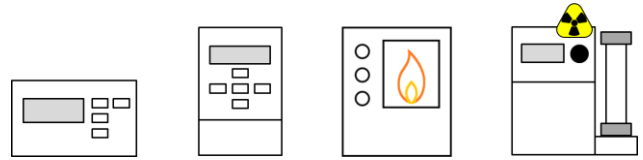


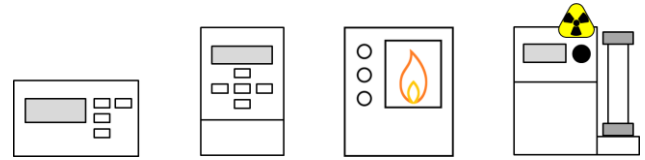
Define the full instrument performance curve, similar to PN-PEMS

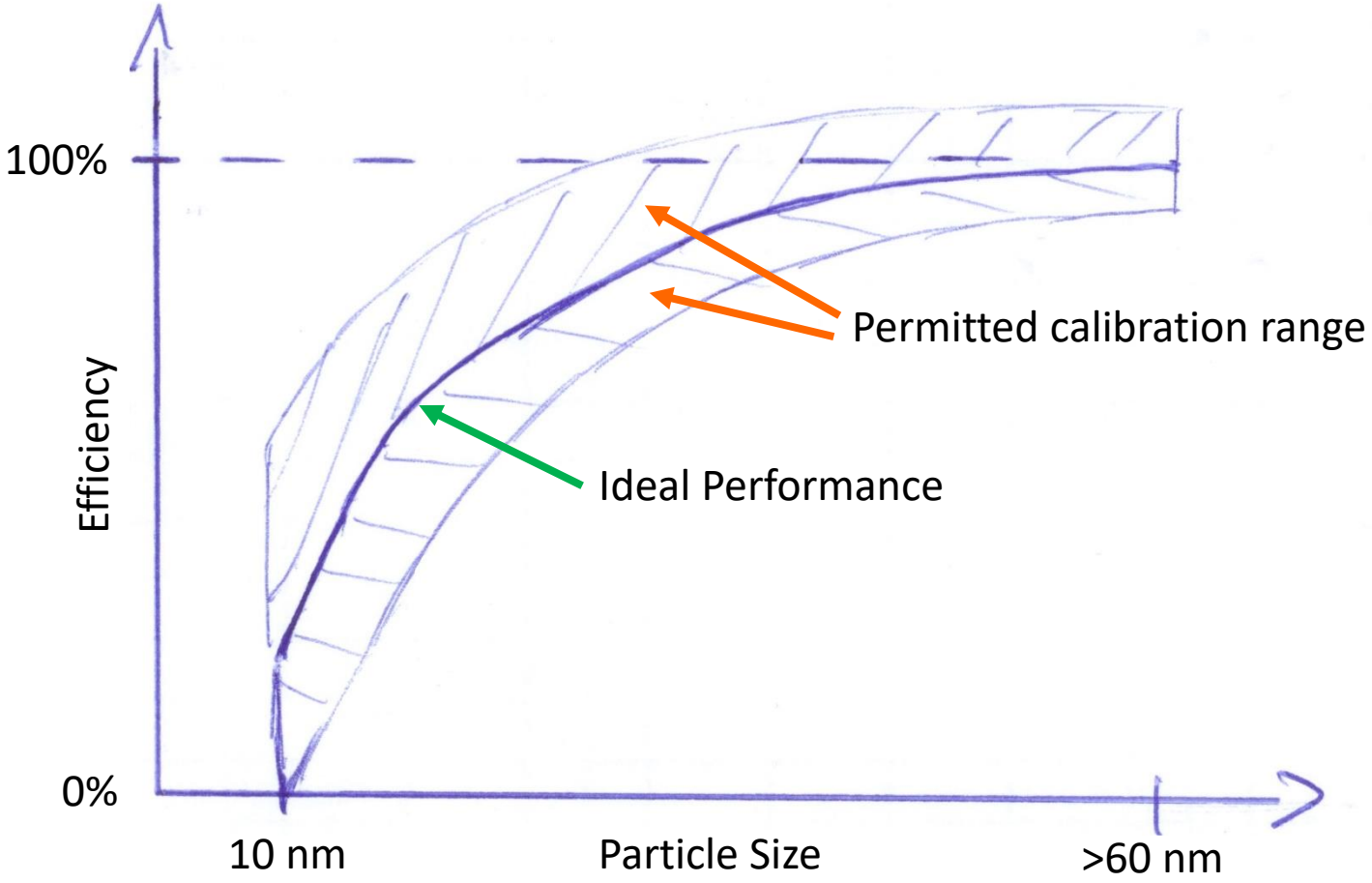
to be discussed

| Size [nm] | (10) | 15 | 23 | 41 | 60-80 | (100) |
|---|---|---|---|---|---|---|
| **System efficiency (23nm)** | 0 | <5% | 47±12% | >90 | 102% | 102% |
| **Imaginable efficiency (10nm)** | <50% | 40-80% | 60-90% | 80-100% | 90-110% | 90-110% |

- Numbers **highly dependent** on the available VPR (CS/ET) technology → **benchmarking** required!
- Direct visual representation of the actual device performance (unlike separated KF+CPC+PCRF curve)
- 10nm point could be omitted, since performance directly related to 15nm (mostly diffusion losses) and calibration error is largest at 10nm!
- A point at 60-80nm could be used instead of 100nm for easier calibration: very similar performance to 100nm, but higher concentration and use of shorter DMA possible
- *No pointless discussion, what an arbitrary "new PCRF" would look like*

# CALIBRATION CONCEPT





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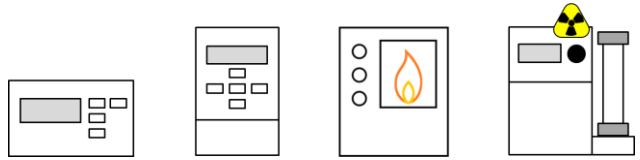


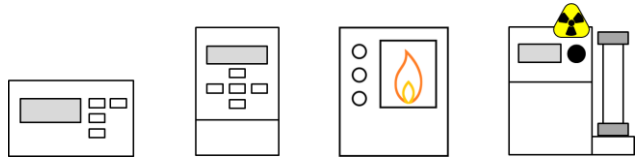
**Calibration is closely linked to instrument definition.**

You cannot decide on one without the other.

Proposal: 2-part calibration

- CPC linearity: calibration of CPC linearity from 1.000-25.000 #/cm³ (tbd)
  - Measured at >20nm (plateau)
  - Error definition: residual errors <5%
- Whole System counting efficiency at 15nm, 23nm, 41nm, 60-80nm
  - incorporates both VPR penetration and CPC counting efficiency
  - single normalization factor at 60-80nm to adjust curve to “100%”
  - a certain minimal penetration through the VPR should be required
  - CPC counting efficiency **does not** need to be calibrated, since lower cutoff is determined by VPR penetration while CPC plateau efficiency is stable
  - High dilution factors (up to 1:3000) not needed anymore with current engines

# CALIBRATION AEROSOL



**Priorities**

– Define a single standard aerosol to end current confusion and enable traceability and accreditation

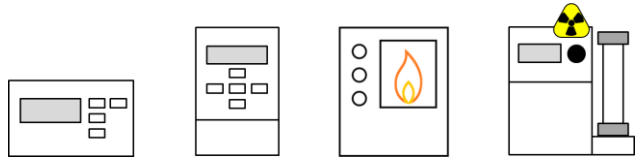
– Aerosol suitable for CPC and VPR

– Compatibility with (future) PN-PEMS calibration

– Thermally stable aerosol (clear definition of “what is thermally stable”)

– Ease of use and cost efficient operation

# CALIBRATION AEROSOL



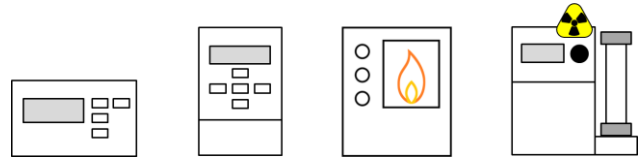
Instruments that work and are comparable:

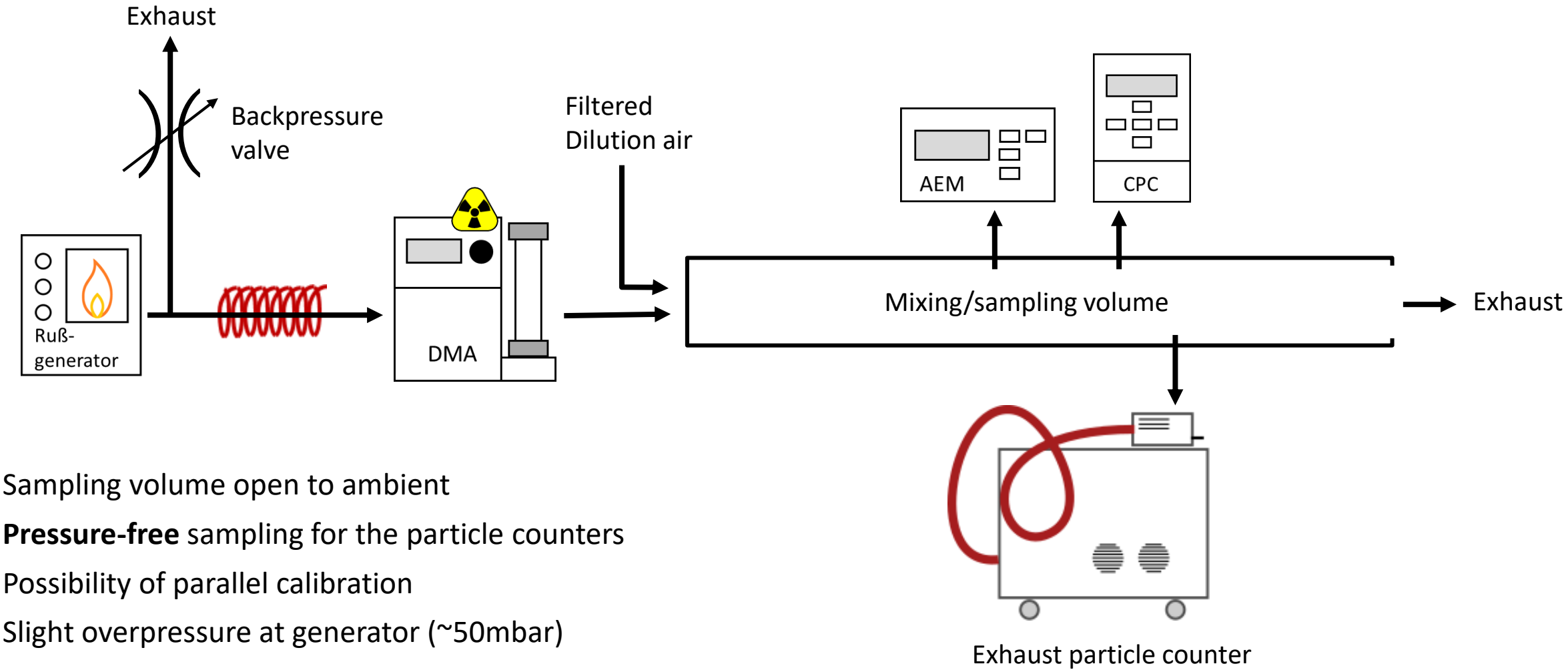
- Propane diffusion-flame “CAST” at stoichiometric/lean combustion mixture
  - Ess, Vasilatou 2019: Characterization of a new miniCAST with diffusion flame and premixed flame options: Generation of articles with high EC content in the size range 30nm to 200nm
  - Andres (2013): EMRP ENV02 PartEmission, D1.1.2, Temperature resistant aerosol standards at 30 nm, 50 nm and 100 nm for number concentration calibration
- Spark discharge graphite “Palas DNP” (at least down to 15nm)
  - Meuller (2012) Review of Spark Discharge Generators for Production of Nanoparticle Aerosols

Devices that could be used through a **transfer function** from the standard:

- Silver nucleation oven ➔ not validated for whole exhaust counter, input necessary
- NaCl nebulizer/drier ➔ strong influence on CPC cutoff, input necessary

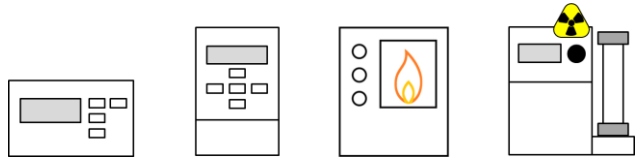
# CALIBRATION SETUP






- Sampling volume open to ambient
- **Pressure-free** sampling for the particle counters
- Possibility of parallel calibration
- Slight overpressure at generator (~50mbar)

# DISCUSSION



Pro

- Applicable to **PMP-compliant and PN-PEMS** counters
- A single, straightforward standard enables **traceability and accreditation**
- A single calibration sheet and curve directly tells the device performance to the user
- Aerosol similar to engine exhaust
- Direct comparison to PN-PEMS
- Less calibration testing required
- Higher accuracy: one instead of two combined calibration curves for counting efficiency
- High error associated with $D_{50}$ calibration avoided

Contra

- Different calibration procedure from PN-23nm
  ➔ but compatible with PEMS calibration lines
- CPC cannot be swapped out without recalibration
  ➔ questionable even today, because it would mean having 2 different calibration dates
- Possible requirement of transfer function or transfer value to current procedure

# Backup

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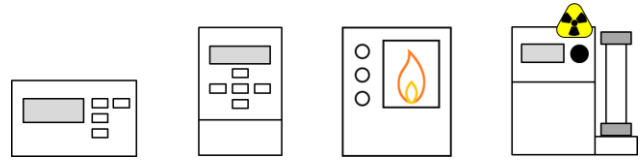

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