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Optimization of calibration interval based on equipment metrological history

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FOREWORD

- Calibration needed to ensure traceability to the international system of units
- Periodic calibration is a tool to ensure that no significant drift has occured during the elapsed period
- IMS often required to comply with ISO/IEC 17025
  - Clause 6.4.7 ”The laboratory shall establish a calibration programme, which shall be reviewed and adjusted as necessary in order to maintain confidence in the status of calibration”
- Reference dosemeters expired (fading, natural background…) and cannot be used for an infinite number of time
- Need to balance cost, process efficiency and quality

How to define/ optimize efficiently calibration period ?

Method	Pros	Cons
Engineering intuition	▪ None	▪ Not quiet reliable ▪ Hard to justify
Manufacturer recommendation	▪ Easy to implement ▪ No detailed knowledge of the instrument needed	▪ May be a starting point BUT if not refined may lead to hazarduous results due to particularities of the measurement process implemented
ILAC-G24 OIML D 10	▪ Document from internationally recognized bodies ▪ 5 methods based on metrology ▪ Generalized methods not specific to particular instruments	▪ Guidance only: detailed implementations not available ▪ Detailed knowledge of the instrument needed

Method 2: Control chart

Prerequisite:

- Uncertainty estimate on measurand
- Uncertainty on the calibration
- System drift measurable
- Calibration data available

METHOD IMPLEMENTATION AND BASIC PRINCIPLES

STEP1: DEFINITION OF DRIFT TOLERANCE

Relative drift tolerance ➔ RT_{drift}

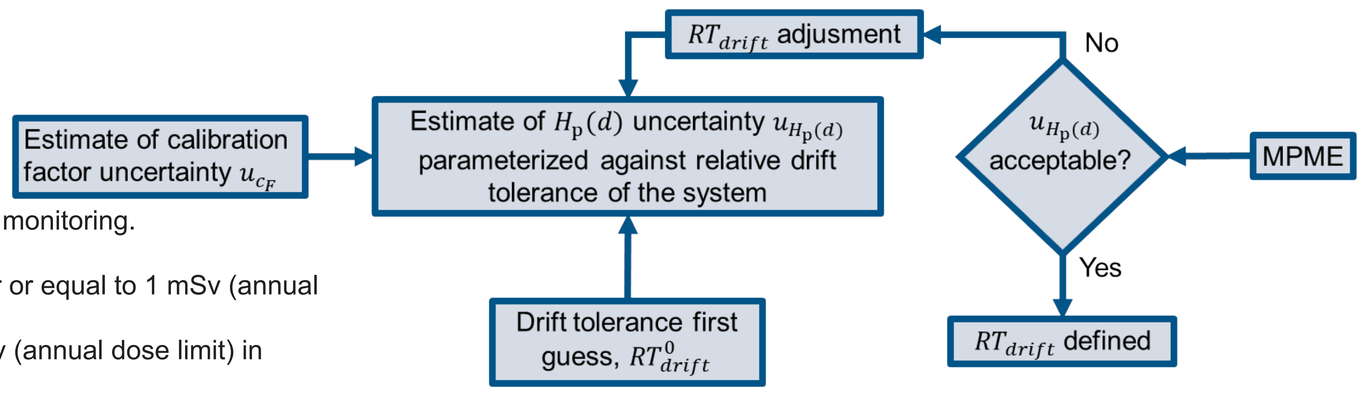
Calibration output ➔ calibration factor c_F

Measurement system output quantity ➔ $H_p(d)$

Maximum permissible measurement error (VIM 4.26) ➔ MPME

Maximum permissible measurement error not standardized for passive individual monitoring.
Suggestion: use maximum recommended value on $u_{Hp(d)}$ in RP160:

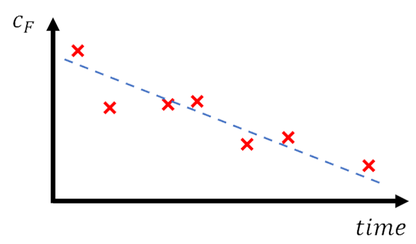
- $H_p(10)$: 30 % at k=1, single field, photons or electrons for a dose level greater or equal to 1 mSv (annual dose limit) in proportion of the wear period
- $H_p(0.07)$: 30 % at k=1, single field, for a dose level greater or equal to 50 mSv (annual dose limit) in proportion of the wear period



STEP 2: DRIFT ASSESSMENT

Single measurement system
No maintenance or maintenance period large enough to cumulate calibration factor data

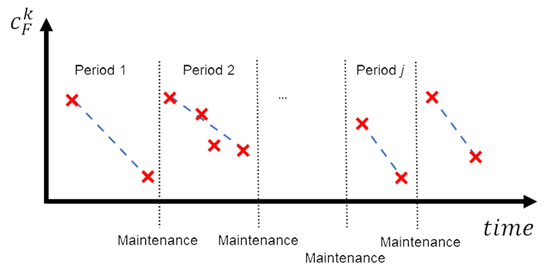
Calibration factor vs elapsed time



Linear fit (dashed blue line)
Drift = slope

Multiple equivalent measurement systems
Maintenance period not large enough to cumulate calibration factor data

Calibration factor vs elapsed time for each reader r



Calibration just before and just after the maintenance (ideal case)

Individual drift d_j^r measured for each period j and each reader k in between two maintenances:

- Two points: linear interpolation
- More than 2 points: linear fit

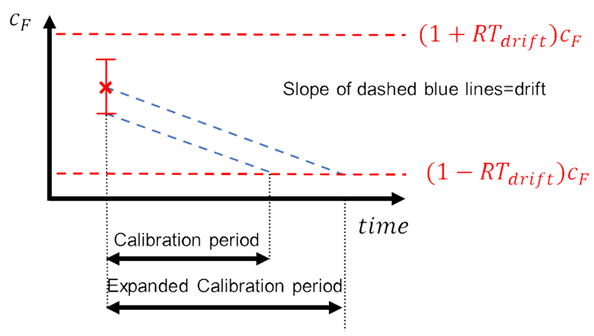
Drift=average of the d_j^r values

$$|Drift| = \max\{|\bar{d} \pm 2\sigma|\}$$

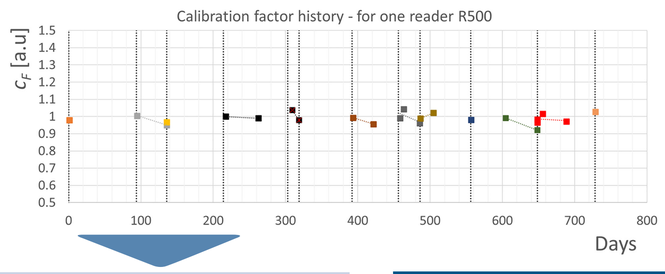
The sign of the drift is given by the sign of $\bar{d} \pm 2\sigma$ associated with $\max\{|\bar{d} \pm 2\sigma|\}$

STEP 3: CALIBRATION PERIOD ESTIMATE

Definition of the (expanded) calibration period



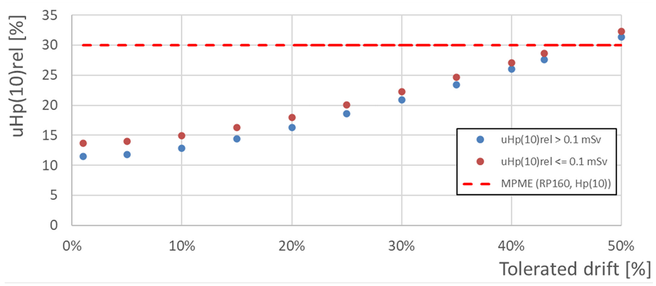
EXAMPLE OF INLIGHT READERS AR500 FOR $H_P(10)$



Extraction of drift values from a reader calibration history with linear interpolation/linear fit

Drift [percent/day]
-0.13
-0.02
...

$\bar{d}$ [percent/day]	-0.012
σ [percent/day]	0.023
$\bar{d}$ - 2σ [percent/day]	-0.057
$\bar{d} + 2\sigma$ [percent/day]	0.034



$RT_{drift} \equiv$ Tolerated drift$|_{u_{rel,H_p(10)}=MPME}$

RT_{drift} = 47 % for MPME=30 % (RP160)
RT_{drift} = 14 % for MPME=16 %

InLight AR500 reader

	RT_{drift} = 47 % MPME=30 %	RT_{drift} = 14 % MPME=16 %
Expanded calibration period [m]	26.9	8.2
Calibration period [m]	23.2	4.5

- Method is easy to implement and does not depend on the measurement system
- Results are obtained based on available data
- Justification of calibration period is based on metrology