

Calibrations at PTW - A short guide

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1 General Information

1.1 Calibration

Calibration is the comparing and - if possible - adjusting of a measuring instrument in such a way that the value displayed shows a traceable connection to the physical quantity measured. For dosimetry this means correlating the dose or dose rate applied to the ionization chamber or detector with the charge or current produced by the chamber and measured by the electrometer.

1.2 Measuring Quantities

Depending on the measuring task different measuring quantities are used in dosimetry:

Absorbed Dose to Water (D_W), measured in water, is the most popular quantity for radiation therapy.

Air Kerma (K_a), measured free in air, is mainly used in diagnostic radiology.

Exposure (J_S), measured free in air, is an older unit used for radiotherapy and radiology.

Ambient or Photon Dose Equivalent ($H^*(10)$, H_x , etc.), measured in air or on a phantom surface, stand for a whole family of radiation protection quantities for personal and area monitoring.

Some additional quantities are used for special situations (e.g. "air kerma strength" for well type chambers, also known as "reference air kerma rate" or RAKR).

1.3 Calibration Procedure

The basis of any calibration is a reference standard calibrated by a National Laboratory. For PTW that means the reference chambers calibrated by the German National Laboratory, PTB. Most simply, calibration means setting up both the reference standard and the customer chamber in the beam and doing a comparison measurement. Normally, though, a transfer standard is involved: The reference chamber is used to either determine the dose rate (for an isotope calibration bench) or calibrate a fixed monitor chamber (for an X-ray calibration bench). This monitor chamber can be a transmission chamber for in air measurements or a compact chamber installed in a phantom tip to tip with the customer chamber for absorbed dose to water measurements. The customer chamber is then fixed in the beam and calibrated with reference to either the known dose rate or the monitor chamber.

Calibration procedures comply with international dosimetry protocols, as stated in the table below.

Table 1.3: Applied dosimetry protocols

Measuring Quantity	Radiation Qualities	Dosimetry Protocol
Absorbed-Dose-To-Water, D_w	^{60}Co	IAEA TRS 398, DIN 6800-2, AAPM's TG-51
Absorbed-Dose-To-Water, D_w	low-energy x-rays (i.e. TW 30), med-energy x-rays (i.e. TH 200)	IAEA TRS 398 (only low-energy x-rays)
Air-Kerma, K_a	RQR-series (i.e. RQR 7), RQA-series (i.e. RQA 5), RQT-series (i.e. RQT 8), RQR M-series (i.e. RQR-M3), RQA M-series (i.e. RQA-M3) / all qualities according IEC 61267	IAEA TRS 457
Ambient Dose Equivalent, $H^*(10)$ Air-Kerma, K_a	N-series (i.e. N-100), ^{137}Cs , ^{60}Co , radiation qualities base on ISO 4037-1:1996	ISO 4037-1

1.4 Calibration Possibilities

Of course, regarding the precision demanded by our customers correct calibrations are of the highest importance. PTW-Freiburg is proud to be a member of the German calibration service (DAkkS, formerly DKD). In fact PTW is the oldest and largest member in this service for dosimetric quantities, thus being the premier German Secondary Standard Laboratory directly traceable to the National Laboratory primary standards by this system. A copy of the annex of our accreditation showing the measuring quantities and measuring ranges accredited for secondary standard service is attached below. To guarantee the continuity of the high quality of PTW calibrations reference instruments are exchanged with the national laboratory every two years; control calibrations of all transfer standards are done every three months. Furthermore PTW-Freiburg is a member of the IAEA / WHO ring of Secondary Standard Dosimetry Laboratories. Regular comparisons (with RPLD and ionizations chambers) are taking place with the International Atomic Energy Agency (IAEA) in Vienna. Thus we are certain to have a good basis to our calibrations and to be in agreement with international standards.

To produce a correct calibration the calibration laboratory of course has to know the measuring quantities (absorbed dose to water, air kerma, exposure or ambient dose equivalent), additional parameters (reference temperature 20 °C or 22 °C), the desired type of calibration (factory calibration or formal DAkkS secondary standard calibration) and the beam qualities for which the instrument has to be calibrated.

1.5 Calibration types

1.5.1 Factory calibration

All calibrations which are not decorated by a special official status are factory calibrations. As every other calibration at PTW factory calibrations are traceable to national or international standards.

Radiological calibrations are done according to the list „typical calibrations at PTW-Freiburg“ (attached below). For all new ionization chambers a calibration with one measuring quantity at one calibration point (this point may be a small series of points in some cases) is included without extra cost. With therapy chambers this is typically ^{60}Co ; if required it can be the series of X-ray qualities TH 70 (TH 100, TH 140) - TH 280. With diagnostic chambers it is either the series 50 kV - 150 kV (RQR or RQA series) or the standard mammography series (RQR-M or RQA-M series) plus the mammography qualities in the MRV or MRH, WAVa or WAHa, WRV or WRH, WSV or WSH, RRV or RRH, WCV or WCH, WTV or WTH, MCV or MCH, RSV or RSH and RCV or RCH series (according to the PTB definition/denotation).

A hint to further calibration possibilities is given by chapter 2 (Calibration facilities and qualities). Nuclide calibrator calibrations are only possible for CURIEMENTOR/CURIETEST instruments.

Well-type chambers for the measurement of afterloading sources are calibrated for Nucletron microSelectron, Varian, Sauerwein (all ^{192}Ir) and BEBIG (^{192}Ir / ^{60}Co) sources.

Furthermore, we offer kV (PPV), mAs and time calibrations.

1.5.2 DAkkS calibration

The DAkkS (formerly DKD) calibration is a calibration formally traceable to a primary standard. It is of the rank of an SSDL (Secondary Standard Dosimetry Laboratory) or an ADCL (Accredited Dosimetry Calibration Laboratory) calibration. Since 1979 PTW-Freiburg maintains a highly respected Secondary Standard Laboratory in the DKD organization (now DAkkS).

At PTW DAkkS (DKD) calibrations are only possible for ionization chambers/dosimeters in the measuring quantities *Absorbed Dose to Water / D_w* , *Air Kerma / K_a* and *Ambient Dose Equivalent / $H^*(10)$* . In case of unusual calibration requirements (e.g. radiation protection calibrations with very low dose rates) the limits of the DAkkS accreditation (see chapter 5 / DAkkS accreditation details) must be observed.

In addition, we offer a DAkkS accredited calibration for the measuring quantity DC voltage, or more precisely the PPV (= practical peak voltage as defined by the standard IEC 61676:2002).

1.5.3 Calibration of non-PTW detectors and dosimeters

PTW provides calibration service for non-PTW detectors and dosimeters under the following conditions:

- a) The detector's intended use and outer geometry are compatible with our capabilities.
- b) The customer can provide user manuals and/or data sheets for the detector and the dosimeter.

1.5.4 Customer Specific Calibration

PTW provides calibration service on request. Please check with the calibration laboratory for feasibility.

1.5.5 Calibration Order

Please use the calibration order sheets FB0045 (therapy/radiation protection) and FB0046 (diagnostic) for optimized order processing in the calibration laboratory (A current version of the calibration order is available for download on the PTW website).

Calibration requests not included in the calibration order forms can be addressed to the calibration laboratory directly. Please note that PTW, in the function of a secondary standard laboratory (SSDL), is only able to pass on measuring quantities previously obtained from a primary standard laboratory (PSDL).

2 Calibration facilities and qualities

2.1 Calibration in Absorbed Dose to Water (D_w)

D_w : 320 kV-Installation Tungsten Anode (GE320-1)

Field size: 10 x 10 cm²

Quality	kV	keV*	Filter	HVL
TH 100	100	46.4	4.5 mm Al	0.18 mm Cu
TH 140	140	65.7	9.0 mm Al	0.43 mm Cu
TH 200	200	109	4.0 mm Al + 1.0 mm Cu	1.67 mm Cu
TH 280	280	163	4.0 mm Al + 3.0 mm Cu	3.40 mm Cu

D_w : 320 kV-Installation Tungsten Anode (GE320-1)

Field size: Ø 3.0 cm

Quality	kV	keV*	Filter	HVL
TW 10	10	6.9	-	0.05 mm Al
TW 15	15	9.2	0.05 mm Al	0.11 mm Al
TW 30	30	16.4	0.50 mm Al	0.44 mm Al
TW 50	50	23.7	1.00 mm Al	1.13 mm Al
TW 70	70	36.4	4.00 mm Al	3.15 mm Al
TW 100	100	46.0	4.50 mm Al	4.68 mm Al

D_w : 160 kV-Installation Tungsten Anode (GE160-1)

Field size: Ø 3.0 cm

Quality	kV	keV*	Filter	HVL
TW 10	10	6.9	-	0.05 mm Al
TW 15	15	9.2	0.05 mm Al	0.10 mm Al
TW 30	30	16.4	0.50 mm Al	0.43 mm Al
TW 50	50	23.7	1.00 mm Al	1.10 mm Al
TW 70	70	36.4	4.00 mm Al	3.10 mm Al
TW 100	100	46.0	4.50 mm Al	4.60 mm Al

*) mean energy (air kerma)

D_w : Cs-137 / 9 TBq (250 Ci) (0.662 MeV)

Field size: Ø 10 cm

D_w : Co-60 / 220 TBq (6000 Ci) (1.330 MeV)

Field size: 10 x 10 cm²

D_w : Co-60 / 220 TBq (6000 Ci) (1.330 MeV)

Field size: 10 x 10 cm²

2.2 Calibration in Air Kerma (K_a)

K_a : 35 kV-Installation Molybdenum (Mo) Anode (*Mammomat*)

Field size: \varnothing 10.0 cm

Quality	kV	keV*	Filter	HVL
RQR-M1	25	14.9	32 μ m Mo	0.30 mm Al
RQR-M2	28	15.4	32 μ m Mo	0.33 mm Al
RQR-M3	30	15.7	32 μ m Mo	0.35 mm Al
RQR-M4	35	16.3	32 μ m Mo	0.38 mm Al

Quality	kV	keV*	Filter	HVL
RQA-M1	25	18.3	32 μ m Mo + 2.0 mm Al	0.55 mm Al
RQA-M2	28	19.0	32 μ m Mo + 2.0 mm Al	0.59 mm Al
RQA-M3	30	19.5	32 μ m Mo + 2.0 mm Al	0.61 mm Al
RQA-M4	35	20.8	32 μ m Mo + 2.0 mm Al	0.68 mm Al

Quality	kV	keV*	Filter	HVL
MRV 25	25	15.8	25 μ m Rh	0.36 mm Al
MRV 28	28	16.3	25 μ m Rh	0.39 mm Al
MRV 30	30	16.5	25 μ m Rh	0.40 mm Al
MRV 35	35	17.0	25 μ m Rh	0.43 mm Al

Quality	kV	keV*	Filter	HVL
MRH 25	25	19.3	25 μ m Rh + 2.0 mm Al	0.61 mm Al
MRH 28	28	19.6	25 μ m Rh + 2.0 mm Al	0.65 mm Al
MRH 30	30	19.9	25 μ m Rh + 2.0 mm Al	0.66 mm Al
MRH 35	35	20.9	25 μ m Rh + 2.0 mm Al	0.71 mm Al

K_a : 35 kV-Installation Tungsten (W) Anode (*Mammomat*)

Field size: \varnothing 10.0 cm

Quality	kV	keV*	Filter	HVL
WAVa 25	25	17.2	0.7 mm Al	0.40 mm Al
WAVa 28	28	18.2	0.7 mm Al	0.46 mm Al
WAVa 30	30	18.8	0.7 mm Al	0.49 mm Al
WAVa 35	35	20.1	0.7 mm Al	0.60 mm Al

Quality	kV	keV*	Filter	HVL
WAHa 25	25	20.4	0.7 mm Al + 2.0 mm Al	0.77 mm Al
WAHa 28	28	21.9	0.7 mm Al + 2.0 mm Al	0.92 mm Al
WAHa 30	30	22.8	0.7 mm Al + 2.0 mm Al	1.03 mm Al
WAHa 35	35	24.9	0.7 mm Al + 2.0 mm Al	1.27 mm Al

Quality	kV	keV*	Filter	HVL
WRV 25	25	17.6	50 µm Rh	0.48 mm Al
WRV 28	28	18.0	50 µm Rh	0.53 mm Al
WRV 30	30	18.2	50 µm Rh	0.54 mm Al
WRV 35	35	18.8	50 µm Rh	0.58 mm Al

Quality	kV	keV*	Filter	HVL
WRH 25	25	20.0	50 µm Rh + 2.0 mm Al	0.71 mm Al
WRH 28	28	20.4	50 µm Rh + 2.0 mm Al	0.76 mm Al
WRH 30	30	20.7	50 µm Rh + 2.0 mm Al	0.78 mm Al
WRH 35	35	22.2	50 µm Rh + 2.0 mm Al	0.89 mm Al

Quality	kV	keV*	Filter	HVL
WSV 25	25	17.9	50 µm Ag	0.44 mm Al
WSV 28	28	18.7	50 µm Ag	0.52 mm Al
WSV 30	30	18.9	50 µm Ag	0.54 mm Al
WSV 35	35	19.6	50 µm Ag	0.59 mm Al

Quality	kV	keV*	Filter	HVL
WSH 25	25	20.7	50 µm Ag + 2.0 mm Al	0.72 mm Al
WSH 28	28	21.6	50 µm Ag + 2.0 mm Al	0.86 mm Al
WSH 30	30	21.9	50 µm Ag + 2.0 mm Al	0.89 mm Al
WSH 35	35	22.9	50 µm Ag + 2.0 mm Al	0.98 mm Al

K_a: 49 kV-Installation Tungsten (W) Anode (MAM3)

Field size: Ø 10.0 cm

Quality	kV	keV*	Filter	HVL
WAVa 20	20	-	0.7 mm Al	0.28 mm Al
WAVa 23	23	15.8	0.7 mm Al	0.35 mm Al
WAVa 25	25	17.2	0.7 mm Al	0.39 mm Al
WAVa 28	28	18.2	0.7 mm Al	0.44 mm Al
WAVa 30	30	18.8	0.7 mm Al	0.48 mm Al
WAVa 35	35	20.1	0.7 mm Al	0.59 mm Al
WAVa 40	40	-	0.7 mm Al	0.66 mm Al
WAVa 45	45	-	0.7 mm Al	0.73 mm Al
WAVa 49	49	-	0.7 mm Al	0.79 mm Al

Quality	kV	keV*	Filter	HVL
WAHa 25	25	20.4	0.7 mm Al + 2.0 mm Al	0.74 mm Al
WAHa 28	28	21.9	0.7 mm Al + 2.0 mm Al	0.88 mm Al
WAHa 30	30	22.8	0.7 mm Al + 2.0 mm Al	1.00 mm Al
WAHa 35	35	24.9	0.7 mm Al + 2.0 mm Al	1.23 mm Al

Quality	kV	keV*	Filter	HVL
WRV 20	20	15.6	50 µm Rh	0.32 mm Al
WRV 23	23	16.6	50 µm Rh	0.40 mm Al
WRV 25	25	17.6	50 µm Rh	0.44 mm Al
WRV 28	28	18.0	50 µm Rh	0.47 mm Al
WRV 30	30	18.2	50 µm Rh	0.49 mm Al
WRV 35	35	18.8	50 µm Rh	0.54 mm Al
WRV 40	40	19.5	50 µm Rh	0.58 mm Al
WRV 45	45	-	50 µm Rh	0.62 mm Al
WRV 49	49	-	50 µm Rh	0.66 mm Al

Quality	kV	keV*	Filter	HVL
WRH 25	25	20.0	50 µm Rh + 2.0 mm Al	0.72 mm Al
WRH 28	28	20.4	50 µm Rh + 2.0 mm Al	0.77 mm Al
WRH 30	30	20.7	50 µm Rh + 2.0 mm Al	0.80 mm Al
WRH 35	35	22.2	50 µm Rh + 2.0 mm Al	0.91 mm Al

Quality	kV	keV*	Filter	HVL
WSV 20	20	15.7	50 µm Ag	0.31 mm Al
WSV 23	23	-	50 µm Ag	0.39 mm Al
WSV 25	25	17.9	50 µm Ag	0.43 mm Al
WSV 28	28	18.7	50 µm Ag	0.50 mm Al
WSV 30	30	18.9	50 µm Ag	0.53 mm Al
WSV 35	35	19.6	50 µm Ag	0.58 mm Al
WSV 40	40	20.2	50 µm Ag	0.62 mm Al
WSV 45	45	-	50 µm Ag	0.67 mm Al
WSV 49	49	-	50 µm Ag	0.70 mm Al

Quality	kV	keV*	Filter	HVL
WSH 25	25	20.7	50 µm Ag + 2.0 mm Al	0.76 mm Al
WSH 28	28	21.6	50 µm Ag + 2.0 mm Al	0.87 mm Al
WSH 30	30	21.9	50 µm Ag + 2.0 mm Al	0.90 mm Al
WSH 35	35	22.9	50 µm Ag + 2.0 mm Al	1.01 mm Al

Quality	kV	keV*	Filter	HVL
WCV 40	40	-	300 µm Cu	2.59 mm Al
WCV 45	45	-	300 µm Cu	3.07 mm Al
WCV 49	49	-	300 µm Cu	3.43 mm Al

Quality	kV	keV*	Filter	HVL
WTV 40	40	-	1.1 mm Ti	2.43 mm Al
WTV 45	45	-	1.1 mm Ti	2.88 mm Al
WTV 49	49	-	1.1 mm Ti	3.21 mm Al

K_a: 49 kV-Installation Rhodium (Rh) Anode (Senograph)

Field size: Ø 10.0 cm

Quality	kV	keV*	Filter	HVL
RRV 25	25	15.6	25 µm Rh	0.35 mm Al
RRV 28	28	16.3	25 µm Rh	0.40 mm Al
RRV 30	30	16.7	25 µm Rh	0.42 mm Al
RRV 35	35	17.6	25 µm Rh	0.50 mm Al
RRV 40	40	18.2	25 µm Rh	0.54 mm Al
RRV 45	45	-	25 µm Rh	0.58 mm Al
RRV 49	49	-	25 µm Rh	0.60 mm Al

Quality	kV	keV*	Filter	HVL
RRH 25	25	19.6	25 µm Rh + 2.0 mm Al	0.70 mm Al
RRH 28	28	20.3	25 µm Rh + 2.0 mm Al	0.76 mm Al
RRH 30	30	20.7	25 µm Rh + 2.0 mm Al	0.80 mm Al
RRH 35	35	21.6	25 µm Rh + 2.0 mm Al	0.87 mm Al

Quality	kV	keV*	Filter	HVL
RSV 25	25	-	30 µm Ag	0.37 mm Al
RSV 28	28	-	30 µm Ag	0.42 mm Al
RSV 30	30	-	30 µm Ag	0.45 mm Al
RSV 35	35	-	30 µm Ag	0.53 mm Al
RSV 40	40	-	30 µm Ag	0.57 mm Al
RSV 45	45	-	30 µm Ag	0.60 mm Al
RSV 49	49	-	30 µm Ag	0.63 mm Al

Quality	kV	keV*	Filter	HVL
RCV 40	40	-	250 µm Cu	2.26 mm Al
RCV 45	45	-	250 µm Cu	2.73 mm Al
RCV 49	49	-	250 µm Cu	3.08 mm Al

K_a: 49 kV-Installation Molybdenum (Mo) Anode (Senograph)

Field size: Ø 10.0 cm

Quality	kV	keV*	Filter	HVL
MMV 22	22	-	32 µm Mo	0.27 mm Al
RQR-M1	25	14.9	32 µm Mo	0.31 mm Al
RQR-M2	28	15.4	32 µm Mo	0.35 mm Al
RQR-M3	30	15.7	32 µm Mo	0.37 mm Al
RQR-M4	35	16.3	32 µm Mo	0.40 mm Al
MMV 40	40	16.7	32 µm Mo	0.42 mm Al
MMV 45	45	-	32 µm Mo	0.44 mm Al
MMV 49	49	-	32 µm Mo	0.46 mm Al

Quality	kV	keV*	Filter	HVL
RQA-M1	25	18.3	32 µm Mo + 2.0 mm Al	0.57 mm Al
RQA-M2	28	19.0	32 µm Mo + 2.0 mm Al	0.61 mm Al
RQA-M3	30	19.5	32 µm Mo + 2.0 mm Al	0.63 mm Al
RQA-M4	35	20.8	32 µm Mo + 2.0 mm Al	0.71 mm Al

Quality	kV	keV*	Filter	HVL
MRV 22	22	-	25 µm Rh	0.30 mm Al
MRV 25	25	15.8	25 µm Rh	0.36 mm Al
MRV 28	28	16.3	25 µm Rh	0.39 mm Al
MRV 30	30	16.5	25 µm Rh	0.40 mm Al
MRV 35	35	17.0	25 µm Rh	0.44 mm Al
MRV 40	40	17.4	25 µm Rh	0.47 mm Al
MRV 45	45	-	25 µm Rh	0.49 mm Al
MRV 49	49	-	25 µm Rh	0.51 mm Al

Quality	kV	keV*	Filter	HVL
MRH 25	25	19.3	25 µm Rh + 2.0 mm Al	0.65 mm Al
MRH 28	28	19.6	25 µm Rh + 2.0 mm Al	0.67 mm Al
MRH 30	30	19.9	25 µm Rh + 2.0 mm Al	0.69 mm Al
MRH 35	35	20.9	25 µm Rh + 2.0 mm Al	0.74 mm Al

Quality	kV	keV*	Filter	HVL
MCV 40	40	-	250 µm Cu	2.39 mm Al
MCV 45	45	-	250 µm Cu	2.86 mm Al
MCV 49	49	-	250 µm Cu	3.20 mm Al

K_a: 160 kV-Installation Tungsten (W) Anode (GE160-1)

Field size: Ø 3.0 cm

Quality	kV	keV*	Filter	HVL
TW 10	10	6.9	-	0.05 mm Al
TW 15	15	9.2	0.05 mm Al	0.10 mm Al
TW 30	30	16.4	0.50 mm Al	0.43 mm Al
TW 50	50	23.7	1.00 mm Al	1.10 mm Al
TW 70	70	36.4	4.00 mm Al	3.10 mm Al

K_a: 320 kV-Installation Tungsten (W) Anode (GE320-1)

Field size: Ø 3.0 cm

Quality	kV	keV*	Filter	HVL
TW 10	10	6.9	-	0.05 mm Al
TW 15	15	9.2	0.05 mm Al	0.11 mm Al
TW 30	30	16.4	0.50 mm Al	0.44 mm Al
TW 50	50	23.7	1.00 mm Al	1.13 mm Al
TW 70	70	36.4	4.00 mm Al	3.15 mm Al

K_a: 160 kV-Installation Tungsten (W) Anode (GE160-1)

Field size: 40 x 40 cm²

Quality	kV	keV*	Filter	HVL
N-20	20	15.8	1.0 mm Al	0.32 mm Al
N-30	30	23.9	4.0 mm Al	1.15 mm Al
N-40	40	32.5	4.0 mm Al + 0.21 mm Cu	0.084 mm Cu
N-60	60	46.8	4.0 mm Al + 0.60 mm Cu	0.24 mm Cu

K_a: 160 kV-Installation Tungsten (W) Anode (GE160-1)

Field size: Ø 10.0 cm

Quality	kV	keV*	Filter	HVL
RQR 2	40	26.1	2.6 mm Al	1.42 mm Al
RQR 3	50	28.7	2.6 mm Al	1.78 mm Al
RQR 4	60	31.2	2.6 mm Al	2.19 mm Al
RQR 5	70	33.6	3.0 mm Al	2.58 mm Al
RQR 6	80	36.3	3.0 mm Al	3.01 mm Al
RQR 7	90	39.0	3.0 mm Al	3.48 mm Al
RQR 8	100	41.8	3.7 mm Al	3.97 mm Al
RQR 9	120	47.3	3.7 mm Al	5.00 mm Al
RQR 10	150	60.9	5.0 mm Al	6.57 mm Al
RQA 2	40	30.1	6.6 mm Al	2.2 mm Al
RQA 3	50	37.3	12.6 mm Al	3.8 mm Al
RQA 4	60	44.2	18.6 mm Al	5.4 mm Al
RQA 5	70	50.5	24.0 mm Al	6.8 mm Al
RQA 6	80	56.9	29.0 mm Al	8.2 mm Al
RQA 7	90	62.4	33.0 mm Al	9.2 mm Al
RQA 8	100	67.7	37.7 mm Al	10.1 mm Al
RQA 9	120	78.1	43.7 mm Al	11.6 mm Al
RQA 10	150	96.0	50.0 mm Al	13.3 mm Al

*) mean energy (air kerma)

K_a: 150 kV-Installation Tungsten (W) Anode (*Epsilon2*)

Field size: Ø 10 cm; 20 cm

Quality	kV	keV*	Filter	HVL
RQR 2	40	26.1	2.51 mm Al	1.42 mm Al
RQR 3	50	28.7	2.37 mm Al	1.78 mm Al
RQR 4	60	31.2	2.51 mm Al	2.19 mm Al
RQR 5	70	33.6	2.64 mm Al	2.58 mm Al
RQR 6	80	36.3	2.71 mm Al	3.01 mm Al
RQR 7	90	39.0	2.86 mm Al	3.48 mm Al
RQR 8	100	41.8	3.03 mm Al	3.97 mm Al
RQR 9	120	47.3	3.42 mm Al	5.00 mm Al
RQR 10	150	60.9	4.05 mm Al	6.57 mm Al
RQA 2	40	30.1	6.53 mm Al	2.2 mm Al
RQA 3	50	37.3	12.39 mm Al	3.8 mm Al
RQA 5	70	50.5	23.61 mm Al	6.8 mm Al
RQA 7	90	62.4	32.86 mm Al	9.2 mm Al
RQA 9	120	78.1	43.42 mm Al	11.6 mm Al
RQA 10	150	96.0	49.10 mm Al	13.3 mm Al

K_a: 320 kV-Installation Tungsten (W) Anode (*GE320-1*)

Field size: 10 x 10 cm²

Quality	kV	keV*	Filter	HVL
TH 70	70	37.4	4.0 mm Al	0.10 mm Cu
TH 100	100	46.8	4.5 mm Al	0.18 mm Cu
TH 140	140	66.2	9.0 mm Al	0.43 mm Cu
TH 200	200	110	4.0 mm Al + 1.0 mm Cu	1.67 mm Cu
TH 280	280	166	4.0 mm Al + 3.0 mm Cu	3.40 mm Cu

*) mean energy (air kerma)

K_a: 320 kV-Installation Tungsten (W) Anode (GE320-1)

Field size: 30 x 30 cm²

Quality	kV	keV*	Filter [mm]				HVL
			Al	Cu	Sn	Pb	
N-20	20	15.3	1.0	-	-	-	0.36 mm Al
N-30	30	23.4	4.0	-	-	-	1.18 mm Al
N-40	40	32.1	4.0	0.21	-	-	0.08 mm Cu
N-60	60	46.7	4.0	0.6	-	-	0.22 mm Cu
N-80	80	64.1	4.0	2.0	-	-	0.60 mm Cu
N-100	100	83.2	4.0	5.0	-	-	1.15 mm Cu
N-150	150	119	4.0	-	2.5	-	2.43 mm Cu
N-200	200	166	4.0	2.0	3.0	1.0	4.06 mm Cu
N-250	250	210	4.0	-	2.0	3.0	5.24 mm Cu
N-300	300	251	4.0	-	3.0	5.0	6.20 mm Cu

*) mean energy (air kerma)

K_a: 150 kV-Installation Tungsten (W) Anode (Epsilon2)

Field size: Ø 10 cm

Quality	kV	Filter	HVL
DT50	50	8.37 mm Al	3.3 mm Al
DT70	70	8.64 mm Al	4.7 mm Al
DT90	90	8.86 mm Al	6.0 mm Al
DTCu50	50	8.37 mm Al + 0.5 mm Cu	4.8 mm Al
DTCu70	70	8.64 mm Al + 0.5 mm Cu	7.2 mm Al
DTCu90	90	8.86 mm Al + 0.5 mm Cu	8.9 mm Al

K_a: Cs-137 / 5,5 TBq (150 Ci) (0.662 MeV)

Field size: Ø 22.0 cm (therapy); Ø 40.0 cm; Ø 60.0 cm; Ø 80.0 cm (radiation protection)

K_a: Cs-137 / 50 GBq (1,35 Ci) (0.662 MeV)

Field size: Ø 40.0 cm; Ø 60.0 cm; Ø 80.0 cm (radiation protection)

K_a: Co-60 / 35 GBq (0,95 Ci) (1.330 MeV)

Field size: Ø 40.0 cm; Ø 60.0 cm; Ø 80.0 cm (radiation protection)

K_a: Co-60 / 220 TBq (6000 Ci) (1.330 MeV)

Field size: 10 x 10 cm²

K_a: Co-60 / 220 TBq (6000 Ci) (1.330 MeV)

Field size: 10 x 10 cm²

2.3 Calibration in Air Kerma Area Product ($K_a \cdot A$)

$K_a \cdot A$: 300 kV-Installation Tungsten (W) Anode (*Stabilipan II*)

Field size: 9 x 9 cm²

Quality	kV	keV*	Filter	HVL
RQR 2	40	26.1	1.33 mm Al	1.42 mm Al
RQR 3	50	28.7	1.33 mm Al	1.78 mm Al
RQR 5	70	33.6	1.33 mm Al	2.58 mm Al
RQR 7	90	39.0	2.00 mm Al	3.48 mm Al
RQR 8	100	41.8	2.00 mm Al	3.97 mm Al
RQR 9	120	47.3	2.70 mm Al	5.00 mm Al
RQR 10	150	60.9	3.50 mm Al	6.57 mm Al

$K_a \cdot A$: 160 kV-Installation Tungsten (W) Anode (*GE160-1*)

Field size: 9 x 9 cm²

Quality	kV	keV*	Filter	HVL
RQR 2	40	30.1	2.6 mm Al	1.42 mm Al
RQR 3	50	37.3	2.6 mm Al	1.78 mm Al
RQR 5	70	50.5	3.0 mm Al	2.58 mm Al
RQR 7	90	62.4	3.0 mm Al	3.48 mm Al
RQR 8	100	67.7	3.7 mm Al	3.97 mm Al
RQR 9	120	78.1	3.7 mm Al	5.00 mm Al
RQR 10	150	96.0	5.0 mm Al	6.57 mm Al

2.4 Calibration in Air Kerma Length Product ($K_a \cdot L$)

$K_a \cdot L$: 160 kV-Installation Tungsten (W) Anode (GE160-1)

Field size: 7.9 cm (field length)

Quality	kV	keV*	Filter	HVL
RQT 8	100	58.6	3.7 mm Al + 0.20 mm Cu	6.9 mm Al
RQT 9	120	65.4	3.7 mm Al + 0.25 mm Cu	8.4 mm Al
RQT 10	150	74.7	4.3 mm Al + 0.30 mm Cu	10.1 mm Al
RQR 5	70	33.6	3.0 mm Al	2.58 mm Al
RQR 7	90	39.0	3.0 mm Al	3.48 mm Al
RQR 9	120	47.3	3.7 mm Al	5.00 mm Al
RQR 10	150	60.9	5.0 mm Al	6.57 mm Al
RQA 5	70	50.5	24.0 mm Al	6.8 mm Al
RQA 7	90	62.4	33.0 mm Al	9.2 mm Al
RQA 9	120	78.1	43.7 mm Al	11.6 mm Al
RQA 10	150	96.0	50.0 mm Al	13.3 mm Al

$K_a \cdot L$: 150 kV-Installation Tungsten (W) Anode (Epsilon2)

Field size: 8.0 cm (field length)

Quality	kV	keV*	Filter	HVL
RQT 8	100	58.6	3.03 mm Al + 0.20 mm Cu	7.0 mm Al
RQT 9	120	65.4	3.42 mm Al + 0.25 mm Cu	8.5 mm Al
RQT 10	150	74.7	4.05 mm Al + 0.30 mm Cu	10.3 mm Al
RQR 5	70	33.6	2.64 mm Al	2.58 mm Al
RQR 7	90	39.0	2.86 mm Al	3.48 mm Al
RQR 9	120	47.3	3.42 mm Al	5.00 mm Al
RQR 10	150	60.9	4.05 mm Al	6.57 mm Al
RQA 5	70	50.5	23.61 mm Al	6.8 mm Al
RQA 7	90	62.4	32.86 mm Al	9.2 mm Al
RQA 9	120	78.1	43.42 mm Al	11.6 mm Al
RQA 10	150	96.0	49.10 mm Al	13.3 mm Al

*) mean energy (air kerma)

2.5 Calibration in Exposure (J_s)

J_s: 35 kV-Installation Molybdenum (Mo) Anode (*Mammomat*)

Field size: Ø 10.0 cm

Quality	kV	keV*	Filter	HVL
RQR-M1	25	14.9	32 µm Mo	0.30 mm Al
RQR-M2	28	15.4	32 µm Mo	0.33 mm Al
RQR-M3	30	15.7	32 µm Mo	0.35 mm Al
RQR-M4	35	16.3	32 µm Mo	0.38 mm Al

Quality	kV	keV*	Filter	HVL
RQA-M1	25	18.3	32 µm Mo + 2.0 mm Al	0.55 mm Al
RQA-M2	28	19.0	32 µm Mo + 2.0 mm Al	0.59 mm Al
RQA-M3	30	19.5	32 µm Mo + 2.0 mm Al	0.61 mm Al
RQA-M4	35	20.8	32 µm Mo + 2.0 mm Al	0.68 mm Al

Quality	kV	keV*	Filter	HVL
MRV 25	25	15.8	25 µm Rh	0.36 mm Al
MRV 28	28	16.3	25 µm Rh	0.39 mm Al
MRV 30	30	16.5	25 µm Rh	0.40 mm Al
MRV 35	35	17.0	25 µm Rh	0.43 mm Al

Quality	kV	keV*	Filter	HVL
MRH 25	25	19.3	25 µm Rh + 2.0 mm Al	0.61 mm Al
MRH 28	28	19.6	25 µm Rh + 2.0 mm Al	0.65 mm Al
MRH 30	30	19.9	25 µm Rh + 2.0 mm Al	0.66 mm Al
MRH 35	35	20.9	25 µm Rh + 2.0 mm Al	0.71 mm Al

J_s: 35 kV-Installation Tungsten (W) Anode (*Mammomat*)

Field size: Ø 10.0 cm

Quality	kV	keV*	Filter	HVL
WAVa 25	25	17.2	0.7 mm Al	0.40 mm Al
WAVa 28	28	18.2	0.7 mm Al	0.46 mm Al
WAVa 30	30	18.8	0.7 mm Al	0.49 mm Al
WAVa 35	35	20.1	0.7 mm Al	0.60 mm Al

Quality	kV	keV*	Filter	HVL
WAHa 25	25	20.4	0.7 mm Al + 2.0 mm Al	0.77 mm Al
WAHa 28	28	21.9	0.7 mm Al + 2.0 mm Al	0.92 mm Al
WAHa 30	30	22.8	0.7 mm Al + 2.0 mm Al	1.03 mm Al
WAHa 35	35	24.9	0.7 mm Al + 2.0 mm Al	1.27 mm Al

Quality	kV	keV*	Filter	HVL
WRV 25	25	17.6	50 µm Rh	0.48 mm Al
WRV 28	28	18.0	50 µm Rh	0.53 mm Al
WRV 30	30	18.2	50 µm Rh	0.54 mm Al
WRV 35	35	18.8	50 µm Rh	0.58 mm Al

Quality	kV	keV*	Filter	HVL
WRH 25	25	20.0	50 µm Rh + 2.0 mm Al	0.71 mm Al
WRH 28	28	20.4	50 µm Rh + 2.0 mm Al	0.76 mm Al
WRH 30	30	20.7	50 µm Rh + 2.0 mm Al	0.78 mm Al
WRH 35	35	22.2	50 µm Rh + 2.0 mm Al	0.89 mm Al

Quality	kV	keV*	Filter	HVL
WSV 25	25	17.9	50 µm Ag	0.43 mm Al
WSV 28	28	18.7	50 µm Ag	0.51 mm Al
WSV 30	30	18.9	50 µm Ag	0.54 mm Al
WSV 35	35	19.6	50 µm Ag	0.59 mm Al

Quality	kV	keV*	Filter	HVL
WSH 25	25	20.7	50 µm Ag + 2.0 mm Al	0.72 mm Al
WSH 28	28	21.6	50 µm Ag + 2.0 mm Al	0.86 mm Al
WSH 30	30	21.9	50 µm Ag + 2.0 mm Al	0.89 mm Al
WSH 35	35	22.9	50 µm Ag + 2.0 mm Al	0.98 mm Al

J_s: 49 kV-Installation Rhodium (Rh) Anode (*Senograph*)

Field size: Ø 10.0 cm

Quality	kV	keV*	Filter	HVL
RRV 25	25	15.6	25 µm Rh	0.33 mm Al
RRV 28	28	16.3	25 µm Rh	0.39 mm Al
RRV 30	30	16.7	25 µm Rh	0.41 mm Al
RRV 35	35	17.6	25 µm Rh	0.47 mm Al
RRV 40	40	18.2	25 µm Rh	
RRV 45	45	-	25 µm Rh	
RRV 49	49	-	25 µm Rh	

Quality	kV	keV*	Filter	HVL
RRH 25	25	19.6	25 µm Rh + 2.0 mm Al	0.70 mm Al
RRH 28	28	20.3	25 µm Rh + 2.0 mm Al	0.76 mm Al
RRH 30	30	20.7	25 µm Rh + 2.0 mm Al	0.80 mm Al
RRH 35	35	21.6	25 µm Rh + 2.0 mm Al	0.87 mm Al

J_s: 320 kV-Installation Tungsten (W) Anode (GE320-1)

Field size: Ø 3.0 cm

Quality	kV	keV*	Filter	HVL
TW 10	10	6.9	-	0.05 mm Al
TW 15	15	9.2	0.05 mm Al	0.11 mm Al
TW 30	30	16.4	0.50 mm Al	0.44 mm Al
TW 50	50	23.7	1.00 mm Al	1.13 mm Al
TW 70	70	36.4	4.00 mm Al	3.15 mm Al

J_s: 160 kV-Installation Tungsten (W) Anode (GE160-1)

Field size: Ø 3.0 cm

Quality	kV	keV*	Filter	HVL
TW 10	10	6.9	-	0.05 mm Al
TW 15	15	9.2	0.05 mm Al	0.10 mm Al
TW 30	30	16.4	0.50 mm Al	0.43 mm Al
TW 50	50	23.7	1.00 mm Al	1.10 mm Al
TW 70	70	36.4	4.00 mm Al	3.10 mm Al

J_s: 160 kV-Installation Tungsten (W) Anode (GE160-1)

Field size: 40 x 40 cm²

Quality	kV	keV*	Filter	HVL
N-20	20	15.3	1.0 mm Al	0.32 mm Al
N-30	30	23.4	4.0 mm Al	1.15 mm Al
N-40	40	32.1	4.0 mm Al + 0.21 mm Cu	0.084 mm Cu
N-60	60	46.7	4.0 mm Al + 0.60 mm Cu	0.24 mm Cu

J_s: 160 kV-Installation Tungsten (W) Anode (GE160-1)

Field size: Ø 10.0 cm

Quality	kV	keV*	Filter	HVL
RQR 2	40	26.1	2.6 mm Al	1.42 mm Al
RQR 3	50	28.7	2.6 mm Al	1.78 mm Al
RQR 4	60	31.2	2.6 mm Al	2.19 mm Al
RQR 5	70	33.6	3.0 mm Al	2.58 mm Al
RQR 6	80	36.3	3.0 mm Al	3.01 mm Al
RQR 7	90	39.0	3.0 mm Al	3.48 mm Al
RQR 8	100	41.8	3.7 mm Al	3.97 mm Al
RQR 9	120	47.3	3.7 mm Al	5.00 mm Al
RQR 10	150	60.9	5.0 mm Al	6.57 mm Al
RQA 2	40	30.1	6.6 mm Al	2.2 mm Al
RQA 3	50	37.3	12.6 mm Al	3.8 mm Al
RQA 4	60	44.2	18.6 mm Al	5.4 mm Al
RQA 5	70	50.5	24.0 mm Al	6.8 mm Al
RQA 6	80	56.9	29.0 mm Al	8.2 mm Al
RQA 7	90	62.4	33.0 mm Al	9.2 mm Al
RQA 8	100	67.7	37.7 mm Al	10.1 mm Al
RQA 9	120	78.1	43.7 mm Al	11.6 mm Al
RQA 10	150	96.0	50.0 mm Al	13.3 mm Al

*) mean energy (air kerma)

J_s: 320 kV-Installation Tungsten (W) Anode (GE320-1)

Field size: 10 x10 cm²

Quality	kV	keV*	Filter	HVL
TH 70	70	37.2	4.0 mm Al	0.10 mm Cu
TH 100	100	46.4	4.5 mm Al	0.18 mm Cu
TH 140	140	65.8	9.0 mm Al	0.43 mm Cu
TH 200	200	109	4.0 mm Al + 1.0 mm Cu	1.67 mm Cu
TH 280	280	163	4.0 mm Al + 3.0 mm Cu	3.40 mm Cu

*) mean energy (air kerma)

J_s: 320 kV-Installation Tungsten (W) Anode (GE320-1)

Field size: 30 x 30 cm²

Quality	kV	keV*	Filter [mm]				HVL
			Al	Cu	Sn	Pb	
N-20	20	15.3	1.0	-	-	-	0.36 mmAl
N-30	30	23.4	4.0	-	-	-	1.18 mm Al
N-40	40	32.1	4.0	0.21	-	-	0.08 mmCu
N-60	60	46.7	4.0	0.6	-	-	0.24 mm Cu
N-80	80	64.1	4.0	2.0	-	-	0.58 mm Cu
N-100	100	83.2	4.0	5.0	-	-	1.11 mm Cu
N-150	150	119	4.0	-	2.5	-	2.36 mm Cu
N-200	200	166	4.0	2.0	3.0	1.0	3.99 mm Cu
N-250	250	210	4.0	-	2.0	3.0	5.19 mm Cu
N-300	300	251	4.0	-	3.0	5.0	6.20 mm Cu

J_s: 150 kV-Installation Tungsten (W) Anode (Epsilon2)

Field size: Ø 10 cm

Quality	kV	Filter	HVL
DT50	50	8.37 mm Al	3.3 mm Al
DT70	70	8.64 mm Al	4.7 mm Al
DT90	90	8.86 mm Al	6.0 mm Al
DTCu50	50	8.37 mm Al + 0.5 mm Cu	4.8 mm Al
DTCu70	70	8.64 mm Al + 0.5 mm Cu	7.2 mm Al
DTCu90	90	8.86 mm Al + 0.5 mm Cu	8.9 mm Al

J_s: Cs-137 / 5,5 TBq (150 Ci) (0.662 MeV)

Field size: Ø 22.0 cm (therapy); Ø 40.0 cm; Ø 60.0 cm; Ø 80.0 cm (radiation protection)

J_s: Cs-137 / 50 GBq (1,35 Ci) (0.662 MeV)

Field size: Ø 40.0 cm; Ø 60.0 cm; Ø 80.0 cm (radiation protection)

J_s: Co-60 / 35 GBq (0,95 Ci) (1.330 MeV)

Field size: Ø 40.0 cm; Ø 60.0 cm; Ø 80.0 cm (radiation protection)

J_s: Co-60 / 220 TBq (6000 Ci) (1.330 MeV)

Field size: 10 x 10 cm²

J_s: Co-60 / 220 TBq (6000 Ci) (1.330 MeV)

Field size: 10 x 10 cm²

2.6 Calibration in Exposure Area Product ($J_s \cdot A$)

$J_s \cdot A$: 300 kV-Installation Tungsten Anode (*Stabilipan II*)

Field size: 9 x 9 cm²

Quality	kV	keV*	Filter	HVL
RQR 2	40	26.1	1.33 mm Al	1.42 mm Al
RQR 3	50	28.7	1.33 mm Al	1.78 mm Al
RQR 5	70	33.6	1.33 mm Al	2.58 mm Al
RQR 7	90	39.0	2.00 mm Al	3.48 mm Al
RQR 8	100	41.8	2.00 mm Al	3.97 mm Al
RQR 9	120	47.3	2.70 mm Al	5.00 mm Al
RQR 10	150	60.9	3.50 mm Al	6.57 mm Al

$J_s \cdot A$: 160 kV-Installation Tungsten Anode (*GE160-1*)

Field size: 9 x 9 cm²

Quality	kV	keV*	Filter	HVL
RQR 2	40	26.1	2.6 mm Al	1.42 mm Al
RQR 3	50	28.7	2.6 mm Al	1.78 mm Al
RQR 5	70	33.6	3.0 mm Al	2.58 mm Al
RQR 7	90	39.0	3.0 mm Al	3.48 mm Al
RQR 8	100	41.8	3.7 mm Al	3.97 mm Al
RQR 9	120	47.3	3.7 mm Al	5.00 mm Al
RQR 10	150	60.9	5.0 mm Al	6.57 mm Al

2.7 Calibration in Exposure Length Product ($J_s \cdot L$)

$J_s \cdot L$: 160 kV-Installation Tungsten Anode (*GE160-1*)

Field size: 7.9 cm (field length)

Quality	kV	keV*	Filter	HVL
RQT 8	100	58.6	3.7 mm Al + 0.20 mm Cu	6.9 mm Al
RQT 9	120	65.4	3.7 mm Al + 0.25 mm Cu	8.4 mm Al
RQT 10	150	74.7	4.3 mm Al + 0.30 mm Cu	10.1 mm Al
RQR 5	70	33.6	3.0 mm Al	2.58 mm Al
RQR 7	90	39.0	3.0 mm Al	3.48 mm Al
RQR 9	120	47.3	3.7 mm Al	5.00 mm Al
RQR 10	150	60.9	5.0 mm Al	6.57 mm Al
RQA 5	70	50.5	24.0 mm Al	6.8 mm Al
RQA 7	90	62.4	33.0 mm Al	9.2 mm Al
RQA 9	120	78.1	43.7 mm Al	11.6 mm Al
RQA 10	150	96.0	50.0 mm Al	13.3 mm Al

J_s · L: 150 kV-Installation Tungsten Anode (*Epsilon2*)

Field size: 8.0 cm (field length)

Quality	kV	keV*	Filter	HVL
RQT 8	100	58.6	3.03 mm Al + 0.20 mm Cu	7.0 mm Al
RQT 9	120	65.4	3.42 mm Al + 0.25 mm Cu	8.5 mm Al
RQT 10	150	74.7	4.05 mm Al + 0.30 mm Cu	10.3 mm Al
RQR 5	70	33.6	2.64 mm Al	2.58 mm Al
RQR 7	90	39.0	2.86 mm Al	3.48 mm Al
RQR 9	120	47.3	3.42 mm Al	5.00 mm Al
RQR 10	150	60.9	4.05 mm Al	6.57 mm Al
RQA 5	70	50.5	23.61 mm Al	6.8 mm Al
RQA 7	90	62.4	32.86 mm Al	9.2 mm Al
RQA 9	120	78.1	43.42 mm Al	11.6 mm Al
RQA 10	150	96.0	49.10 mm Al	13.3 mm Al

*) mean energy (air kerma)

2.8 Calibration in Ambient Dose Equivalent $H^*(10)$

$H^*(10)$: 160 kV-Installation Tungsten Anode (GE160-1)

Field size: 40 x 40 cm²

Quality	kV	keV*	Filter	HVL
N-30	30	23.4	4.0 mm Al	1.150 mm Al
N-40	40	32.1	4.0 mm Al + 0.21 mm Cu	0.084 mm Cu
N-60	60	46.7	4.0 mm Al + 0.60 mm Cu	0.240 mm Cu

$H^*(10)$: 320 kV-Installation Tungsten (W) Anode (GE320-1)

Field size: 30 x 30 cm²

Quality	kV	keV*	Filter [mm]				HVL
			Al	Cu	Sn	Pb	
N-30	30	23.4	4.0	-	-	-	1.18 mm Al
N-40	40	32.1	4.0	0.21	-	-	0.08 mmCu
N-60	60	46.7	4.0	0.6	-	-	0.24 mm Cu
N-80	80	64.1	4.0	2.0	-	-	0.58 mm Cu
N-100	100	83.2	4.0	5.0	-	-	1.11 mm Cu
N-150	150	119	4.0	-	2.5	-	2.36 mm Cu
N-200	200	166	4.0	2.0	3.0	1.0	3.99 mm Cu
N-250	250	210	4.0	-	2.0	3.0	5.19 mm Cu
N-300	300	251	4.0	-	3.0	5.0	6.20 mm Cu

*) mean energy (air kerma)

$H^*(10)$: Cs-137 / 5,5 TBq (150 Ci) (0.662 MeV)

Field size: Ø 40.0 cm; Ø 60.0 cm; Ø 80.0 cm

$H^*(10)$: Cs-137 / 50 GBq (1,35 Ci) (0.662 MeV)

Field size: Ø 40.0 cm; Ø 60.0 cm; Ø 80.0 cm

$H^*(10)$: Co-60 / 35 GBq (0,95 Ci) (1.330 MeV)

Field size: Ø 40.0 cm; Ø 60.0 cm; Ø 80.0 cm

2.9 Calibration in Photon Dose Equivalent (H_x)

H_x : 160 kV-Installation Tungsten Anode (GE160-1)

Field size: 40 x 40 cm²

Quality	kV	keV*	Filter	HVL
N-20	20	15.3	1.0 mm Al	0.32 mm Al
N-30	30	23.4	4.0 mm Al	1.15 mm Al
N-40	40	32.1	4.0 mm Al + 0.21 mm Cu	0.084 mm Cu
N-60	60	46.7	4.0 mm Al + 0.60 mm Cu	0.24 mm Cu

H_x : 320 kV-Installation Tungsten (W) Anode (GE320-1)

Field size: 30 x 30 cm²

Quality	kV	keV*	Filter [mm]				HVL
			Al	Cu	Sn	Pb	
N-20	20	15.3	1.0	-	-	-	0.36 mmAl
N-30	30	23.4	4.0	-	-	-	1.18 mm Al
N-40	40	32.1	4.0	0.21	-	-	0.08 mmCu
N-60	60	46.7	4.0	0.6	-	-	0.24 mm Cu
N-80	80	64.1	4.0	2.0	-	-	0.58 mm Cu
N-100	100	83.2	4.0	5.0	-	-	1.11 mm Cu
N-150	150	119	4.0	-	2.5	-	2.36 mm Cu
N-200	200	166	4.0	2.0	3.0	1.0	3.99 mm Cu
N-250	250	210	4.0	-	2.0	3.0	5.19 mm Cu
N-300	300	251	4.0	-	3.0	5.0	6.20 mm Cu

*) mean energy (air kerma)

H_x : Cs-137 / 5,5 TBq (150 Ci) (0.662 MeV)

Field size: Ø 40.0 cm; Ø 60.0 cm; Ø 80.0 cm

H_x : Cs-137 / 50 GBq (1,35 Ci) (0.662 MeV)

Field size: Ø 40.0 cm; Ø 60.0 cm; Ø 80.0 cm

H_x : Co-60 / 35 GBq (0,95 Ci) (1.330 MeV)

Field size: Ø 40.0 cm; Ø 60.0 cm; Ø 80.0 cm

3 Type-specific calibration options

For details on calibration conditions please refer to *chapter 2*

Chamber Type	Tube Voltage / Isotope	Possible Measuring Quantities	Typical Calibration Points	Range of Use	Remarks
Ion Chamber C-chamber 0.1 cm ³ 23322	⁶⁰ Co	D _w K _a , J _s	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
	¹³⁷ Cs	D _w K _a , J _s			¹³⁷ Cs-installation 9 TBq (250 Ci)
	200 kV - 280 kV	D _w K _a , J _s			320 kV-installation tungsten anode
Ion Chamber micro chamber 0.1 cm ³ 2332, 23323	⁶⁰ Co	D _w K _a , J _s	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
	¹³⁷ Cs	D _w K _a , J _s			¹³⁷ Cs-installation 9 TBq (250 Ci)
	140 kV - 280 kV	D _w K _a , J _s			320 kV-installation tungsten anode
Ion Chamber compact chamber 1 cm ³ rigid 23331 and 30015	⁶⁰ Co	D _w K _a , J _s	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
	¹³⁷ Cs	D _w K _a , J _s			¹³⁷ Cs-installation 9 TBq (250 Ci)
	140 kV - 280 kV	D _w K _a , J _s			320 kV-installation tungsten anode
	40 kV - 150 kV	K _a , J _s		Diagnostic Radiology	160 kV-installation tungsten anode
Ion Chamber compact chamber 0.3 cm ³ rigid 23332 and 30016	⁶⁰ Co	D _w K _a , J _s	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
	¹³⁷ Cs	D _w K _a , J _s			¹³⁷ Cs-installation 9 TBq (250 Ci)
	140 kV - 280 kV	D _w K _a , J _s			320 kV-installation tungsten anode
	50 kV - 150 kV (RQR / RQA)	K _a , J _s		Diagnostic Radiology	160 kV-installation tungsten anode
Ion Chamber soft X-ray 0.02 cm ³ 23342	15 kV - 70 kV	D _w K _a , J _s	K _a , 15 kV - 70 kV	Radiation Therapy soft X-rays	160 kV-installation tungsten anode
					320 kV-installation tungsten anode
Ion Chamber "Markus" chamber 0.055 cm ³ 23343	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
Ion Chamber soft X-ray 0.2 cm ³ 23344	15 kV - 70 kV	D _w K _a , J _s	K _a , 15 kV - 70 kV	Radiation Therapy soft X-rays	160 kV-installation tungsten anode
					320 kV-installation tungsten anode

Chamber Type	Tube Voltage / Isotope	Possible Measuring Quantities	Typical Calibration Points	Range of Use	Remarks
Ion Chamber compact chamber 30 cm ³ 23361	⁶⁰ Co	K _a , J _s H _x , H*(10)	H*(10), ⁶⁰ Co	radiation protection stray radiation	⁶⁰ Co-installation 35 GBq (0,95 Ci)
	¹³⁷ Cs	K _a , J _s H _x , H*(10)			¹³⁷ Cs-installation 50 GBq (1,35 Ci)
	20 kV - 60 kV	K _a , J _s H _x , H*(10)			160 kV-installation tungsten anode
	60 kV - 250 kV	K _a , J _s H _x , H*(10)			320 kV-installation tungsten anode
	50 kV - 150 kV (RQR /RQA acc. IEC 61267)	K _a , J _s	K _a	Diagnostic Radiology	300 kV-installation tungsten anode 160 kV-installation tungsten anode
Ion Chamber parallel plate chamber 30 cm ³ 233612	50 kV - 150 kV (RQR /RQA acc. IEC 61267)	K _a , J _s	K _a	Diagnostic Radiology	300 kV-installation tungsten anode
					160 kV-installation tungsten anode
Ion Chamber 0.3 cm ³ flex 233641, 31003, 31013	⁶⁰ Co	D _w K _a , J _s	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
	¹³⁷ Cs	D _w K _a , J _s			¹³⁷ Cs-installation 9 TBq (250 Ci)
	140 kV - 280 kV	D _w K _a , J _s			320 kV-installation tungsten anode
Ion Chamber 0.125 cm ³ flex 233642, 31002, 31010	⁶⁰ Co	D _w K _a , J _s	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
	¹³⁷ Cs	D _w K _a , J _s			¹³⁷ Cs-installation 9 TBq (250 Ci)
	140 kV - 280 kV	D _w K _a , J _s			320 kV-installation tungsten anode
Ion Chamber „Farmer“ chambers 0.6 cm ³ 30001, 30006, 30010, 30013	⁶⁰ Co	D _w K _a , J _s	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
	¹³⁷ Cs	D _w K _a , J _s			¹³⁷ Cs-installation 9 TBq (250 Ci)
	100 kV - 280 kV 70 kV - 280 kV	D _w K _a , J _s			320 kV-installation tungsten anode
Ion Chamber „Farmer“ chambers graphite, 0.6 cm ³ 30002, 30004, 30005, 30011, 30012	⁶⁰ Co	D _w K _a , J _s	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
	¹³⁷ Cs	D _w K _a , J _s			¹³⁷ Cs-installation 9 TBq (250 Ci)
	100 kV - 280 kV 70 kV - 280 kV	D _w K _a , J _s			320 kV-installation tungsten anode
Ion Chamber PinPoint chamber 0.015/0.016/0.03 cm ³ 31006, 31009, 31014, 31015, 31016, 31022, 31023	Co-60	D _w K _a , J _s	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
Ion Chamber 0.07 cm ³ semiflex 3D 31021	Co-60	D _w K _a , J _s	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)

Chamber Type	Tube Voltage / Isotope	Possible Measuring Quantities	Typical Calibration Points	Range of Use	Remarks
Ion Chamber 100 cm ³ chamber 32001	¹³⁷ Cs	K _a , J _s , H _x , H*(10)	H*(10), ¹³⁷ Cs	radiation protection	¹³⁷ Cs-installation 50 GBq (1,35 Ci)
Ion Chamber spherical chamber 1 l 32002	¹³⁷ Cs	K _a , J _s , H _x , H*(10)	H*(10), ¹³⁷ Cs	radiation protection stray radiation	¹³⁷ Cs-installation 50 GBq (1,35 Ci)
	N20 - N60	K _a , J _s , H _x , H*(10)			160 kV-installation tungsten anode
	N60 - N250	K _a , J _s , H _x , H*(10)			320 kV-installation tungsten anode
	⁶⁰ Co	K _a , J _s , H _x , H*(10)	H*(10), ⁶⁰ Co		⁶⁰ Co-installation 35 GBq (0,95 Ci)
Ion Chamber spherical chamber 10 l 32003	¹³⁷ Cs	K _a , J _s , H _x , H*(10)	H*(10), ¹³⁷ Cs	radiation protection stray radiation	¹³⁷ Cs-installation 50 GBq (1,35 Ci)
	N20 - N60	K _a , J _s , H _x , H*(10)			160 kV-installation tungsten anode
	N60 - N250	K _a , J _s , H _x , H*(10)			320 kV-installation tungsten anode
	⁶⁰ Co	K _a , J _s , H _x , H*(10)	H*(10), ⁶⁰ Co		⁶⁰ Co-installation 35 GBq (0,95 Ci)
Ion Chamber spherical chamber 30 cm ³ 32005	¹³⁷ Cs	K _a , J _s , H _x , H*(10)	H*(10), ¹³⁷ Cs	radiation protection stray radiation	¹³⁷ Cs-installation 50 GBq (1,35 Ci)
	N20 - N60	K _a , J _s , H _x , H*(10)			160 kV-installation tungsten anode
	N60 - N250	K _a , J _s , H _x , H*(10)			320 kV-installation tungsten anode
	⁶⁰ Co	K _a , J _s , H _x , H*(10)	H*(10), ⁶⁰ Co		⁶⁰ Co-installation 35 GBq (0,95 Ci)
	50 kV - 150 kV (RQR /RQA acc. IEC 61267)	K _a , J _s	K _a	Diagnostic Radiology	300/160 kV- installation tungsten anode
Ion Chamber spherical chamber 3 l 32006	¹³⁷ Cs	K _a , J _s , H _x , H*(10)	H*(10), ¹³⁷ Cs	radiation protection stray radiation	¹³⁷ Cs-installation 50 GBq (1,35 Ci)
	⁶⁰ Co	K _a , J _s , H _x , H*(10)	H*(10), ⁶⁰ Co		⁶⁰ Co-installation 35 GBq (0,95 Ci)
Ion Chamber Neutron Chamber (Kühn) 33051, 33052, 33053, 33054	⁶⁰ Co	K _a	K _a , ⁶⁰ Co		⁶⁰ Co-installation 33 TBq (900 Ci) Test Certificate only
Ion Chamber „Roos“ chamber 0.35 cm ³ 34001	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
Ion Chamber soft X-ray 0.005 cm ³ 34013	15 kV - 70 kV	D _w	K _a 15 kV - 70 kV	Radiation Therapy soft X-rays	160 kV-installation tungsten anode
		K _a , J _s			320 kV-installation tungsten anode

Chamber Type	Tube Voltage / Isotope	Possible Measuring Quantities	Typical Calibration Points	Range of Use	Remarks
Ion Chamber Diamentor chambers 34037	only 70 kV	K _a		Diamentor	300 kV-installation tungsten anode
Ion Chamber „Advanced Markus“ chamber 34045	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
Ion Chamber SFD chamber 75 cm ³ 34060	50 kV - 150 kV (RQR /RQA acc. IEC 61267)	K _a , J _s	K _a / RQR ⁽¹⁾	Diagnostic Radiology	300 kV-installation tungsten anode
					160 kV-installation tungsten anode
Ion Chamber SFD mammography chamber 6 cm ³ 34069	50 kV - 150 kV (RQR /RQA acc. IEC 61267)	K _a , J _s	K _a / RQR ⁽¹⁾	Diagnostic Radiology	300 kV-installation tungsten anode
					160 kV-installation tungsten anode
	25 kV - 35 kV (RQR-M acc. IEC 61267, MRV, WAVa, WRV, WSV acc. PTB)	K _a , J _s	K _a / RQR-M ⁽²⁾	Mammography	35 kV-installation Mo/W anode
					25 kV - 35 kV (RQA-M acc. IEC 61267, MRH, WAHa, WRH, WSH acc. PTB)
25 kV - 35 kV RRV/RRH acc.PTB					
Ion Chamber Bragg-Peak chamber 34070, 34073, 34080	⁶⁰ Co	K _a			⁶⁰ Co-installation 220 TBq (6000 Ci) Test Certificate only
Ion Chamber Diamentor chambers 57523, 57524, 5754, 5755, 5759, 34008, 34010, 34016, 34017, 34018, 34019, 34020, 34028, 34030, 34038, 34039, 34040, 34044, 34048, 34049, 34057, 34063	50 kV - 150 kV (RQR acc. IEC 61267)	K _a · area J _s · area DAP	K _a · area	Diamentor	300 kV-installation tungsten anode
	50 kV - 150 kV (RQR acc. IEC 61267)	K _a · area J _s · area DAP	K _a · area		160 kV-installation tungsten anode
Ion Chamber Diamentor chambers 57554, 34002, 34011, 34052, 34054	40 kV - 150 kV RQR-qualities	K _a · area J _s · area	K _a · area DAP	Diamentor	300 kV-installation tungsten anode
	40 kV - 150 kV RQR-qualities	K _a · area J _s · area			160 kV-installation tungsten anode
Ion Chamber Parallel plate chamber 112 cm ³ 77335 and 7733	50 kV - 150 kV (RQR /RQA acc. IEC 61267)	K _a , J _s	K _a	Diagnostic Radiology	300 kV-installation tungsten anode
					160 kV-installation tungsten anode

(1) a standard calibration comprises an RQR- or RQA-series only, (2) a standard calibration comprises an RQR-M or RQA-M series only

Chamber Type	Tube Voltage / Isotope	Possible Measuring Quantities	Typical Calibration Points	Range of Use	Remarks
Ion Chamber Parallel plate chamber 1 cm ³ 77334, 77337	50 kV - 150 kV (RQR acc. IEC 61267)	K _a , J _s		Diagnostic Radiology	300 kV-installation tungsten anode
	25 kV - 35 kV (RQR-M/RQA-M acc. IEC 61267) MRV/MRH, WAVa/WAHa, WRV/WRH, WSV/WSH acc. PTB)	K _a , J _s	K _a	Mammography	35 kV-installation Mo/W anode
	25 kV - 35 kV RRV/RRH acc. PTB				49 kV-installation Rh/Mo anode
Ion Chamber CT-chamber 77336, 30009, 30017	100 kV - 150 kV (RQT acc. IEC 61267)	K _a · length J _s · length DLP	K _a · length, RQT 9	Diagnostic Radiology	160 kV-installation tungsten anode
Ion Chamber cylindrical chamber 50 l 7262	¹³⁷ Cs	K _a , J _s , H _x , H*(10)	H*(10), ¹³⁷ Cs	radiation protection stray radiation	¹³⁷ Cs-installation 50 GBq (1,35 Ci)
	⁶⁰ Co	K _a , J _s , H _x , H*(10)	H*(10), ⁶⁰ Co		⁶⁰ Co-installation 35 GBq (0,95 Ci)
Diamond 60003	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 33 TBq (900 Ci)
Diode Diados detector Type: 60004	50 kV - 150 kV (RQR /RQA)	K _a , J _s	K _a / RQR ⁽¹⁾	Diagnostic Radiology	160 kV-installation tungsten anode
	50 kV - 90 kV (RQR / RQA acc. IEC 61267)	K _a , J _s	K _a	Dental	300 kV-installation tungsten anode
Diode Diados mammography detector Type: 60005	25 kV - 35 kV (RQR-M/RQA-M acc. IEC 61267) MRV/MRH, WAVa/WAHa, WRV/WRH, WSV/WSH, RRV/RRH acc. PTB)	K _a , J _s	K _a / RQR-M ⁽²⁾	Diagnostic Radiology Mammography	35 kV-installation Mo/W anode
Diode dosimetry diode (E) 60008 / 60012	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 33 TBq (900 Ci)
microDiamond 60019	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
QC6Plus 42007	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 33 TBq (900 Ci)
QUICKCHECKweblin 42031	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)

Chamber Type	Tube Voltage / Isotope	Possible Measuring Quantities	Typical Calibration Points	Range of Use	Remarks
2D-Array 729 10024	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
2D-Array 729 XDR 10031	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Protons	⁶⁰ Co-installation 220 TBq (6000 Ci)
STARCHECK (MR) 10032 / 10043	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
STARCHECKmaxi (MRI) 10033 / 10049	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
OCTAVIUS 1000 SRS 10036	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
OCTAVIUS 729 (XDR) 10040 / 10042	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
OCTAVIUS 1500 (XDR) 10044 / 10051	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
OCTAVIUS 1500 MRI 10050	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
LA 48 34009	⁶⁰ Co	D _w	D _w , ⁶⁰ Co	Radiation Therapy Photons/Electrons	⁶⁰ Co-installation 220 TBq (6000 Ci)
Diamentor C02, C02H Types: 11018 und 11044	40 kV - 120 kV (RQR /IEC61267)	K _a · area DAP	K _a · area DAP	Diagnostic	300 kV-installation tungsten anode
					160 kV-installation tungsten anode
Diamentor C, CX Types: 11027 und 11034, 11034R, 11034RU, 11034U	50 kV - 150 kV (RQR /IEC61267)	K _a · area DAP	K _a · area DAP	Diagnostic	300 kV-installation tungsten anode
					160 kV-installation tungsten anode
Diamentor CI, PX, PX2, CI-P Types: 11042, 11020, 11045, 11046	40 kV - 150 kV (RQR /IEC61267)	K _a · area DAP	K _a · area DAP	Diagnostic	300 kV-installation tungsten anode
					160 kV-installation tungsten anode
Diode Conny, Conny II Types: 11001, 11007	60 kV - 100 kV (RQR / RQA acc. IEC 61267)	K _a	K _a	Diagnostic Radiology	300 kV-installation tungsten anode
	25 kV - 35 kV (RQR-Mx / RQA-Mx acc. IEC 61267)				Mammography

Chamber Type	Possible Calibrations	Measuring Quantities	Isotope	Range of Use	Remarks
SourceCheck 4Pi 33005 <i>Brachy</i>	BEBIG I25.S06 BEBIG I25.S16 BEBIG I25.S17 BEBIG I25.S17plus BARD STM1251 Advantage (IsoAid) selectSeed (Isotron) IsoSeed® Amersham 6711 :	Reference Air Kerma Rate (RAKR) / Apparent Activity	I-125	Nuclear Medicine	Source configuration: single seed, Adapter: T33005.1.100
	RapidStrand 6711	RAKR / Apparent Activity	I-125	Nuclear Medicine	Source configuration: strand, Adapter: T33005.1.120
	IsoCord® : BEBIG I25.S061-10 BEBIG I25.S171-10 BEBIG I25.S17plus1-10	RAKR / Apparent Activity	I-125	Nuclear Medicine	Source configuration: strand, Adapter: T33005.1.130
SourceCheck 4Pi 33005 <i>HDR</i>	Nucletron microSelectron® / microSelectron V2®	RAKR / Apparent Activity	Ir-192	Nuclear Medicine Afterloading	Supported adapters: <ul style="list-style-type: none"> • T33002.1.009 • T33004.1.011 • T33004.1.012 • T33004.1.013
	MDS Nordion GammaMed / Varian GammaMedPlus	RAKR / Apparent Activity	Ir-192	Nuclear Medicine Afterloading	
	Varian Varisource	RAKR / Apparent Activity	Ir-192	Nuclear Medicine Afterloading	
	BEBIG MultiSource type: Ir2.A85-2	RAKR / Apparent Activity	Ir-192	Nuclear Medicine Afterloading	Supported applicators: <ul style="list-style-type: none"> • 11-00207 3 mm Ø steel applicator • 4.7Fr VariSource Plastic Tipped Catheter • LAA 1400-GYN Ø 3mm • Varian GM11002070 Ø 3 mm • Steel needle Ø 1.7 mm
	BEBIG MultiSource (types: GK60M21 and Co0.A86)	RAKR / Apparent Activity	Co-60	Nuclear Medicine Afterloading	
	Nucletron Flexisource Co60	RAKR / Apparent Activity	Co-60	Nuclear Medicine Afterloading	
SourceCheck 34051 <i>Brachy</i>	BEBIG I25.S06 BEBIG I25.S16 BEBIG I25.S17 BEBIG I25.S17plus BARD STM1251 Advantage (IsoAid) selectSeed (Isotron) IsoSeed® Amersham 6711 :	Reference Air Kerma Rate (RAKR) / Apparent Activity	I-125	Nuclear Medicine	Source configuration: single seed, Adapter: T34051.1.060/070
	RapidStrand 6711	RAKR / Apparent Activity			Source configuration: strand, Adapter: T34051.1.102
	IsoCord® : BEBIG I25.S061-10 BEBIG I25.S171-10 BEBIG I25.S17plus1-10	RAKR / Apparent Activity	I-125	Nuclear Medicine	Source configuration: strand, Adapter: T34051.1.080
SourceCheck 34051 <i>HDR</i>	Nucletron microSeletron®	RAKR / Apparent Activity	Ir-192	Nuclear Medicine	Adapter: ProGuide needle 5F, sharp 240 mm

Chamber Type	Possible Calibrations	Measuring Quantities	Isotope	Range of Use	Remarks
HDR-Chamber 33004	Nucletron microSelectron® / microSelectron V2®	RAKR / Apparent Activity	Ir-192	Nuclear Medicine Afterloading	Supported adapters: <ul style="list-style-type: none"> • T33002.1.009 • T33004.1.011 • T33004.1.012 • T33004.1.013 Supported applicators: <ul style="list-style-type: none"> • 11-00207 3 mm Ø steel applicator • 4.7Fr VariSource Plastic Tipped Catheter • LAA 1400-GYN Ø 3mm • Varian GM1 1002070 Ø 3 mm • Steel needle Ø 1.7 mm
	MDS Nordion GammaMed / Varian GammaMedPlus	RAKR / Apparent Activity	Ir-192	Nuclear Medicine Afterloading	
	Varian Varisource	RAKR / Apparent Activity	Ir-192	Nuclear Medicine Afterloading	
	BEBIG MultiSource type: Ir2.A85-2	RAKR / Apparent Activity	Ir-192	Nuclear Medicine Afterloading	
	BEBIG MultiSource (types: GK60M21 and Co0.A86)	RAKR / Apparent Activity	Co-60	Nuclear Medicine Afterloading	
	Nucletron Flexisource Co60	RAKR / Apparent Activity	Co-60	Nuclear Medicine Afterloading	
HDR-Chamber 33002 Nucletron type: 077.091 / 077.092 / 077.093 / 077.094	Nucletron microSeletron	Reference Air Kerma Rate (RAKR) / Apparent Activity	Ir-192	Nuclear Medicine Afterloading	PTW-Adapter: T33002.1.009 / type 33004 source variety available only on request
HDR-Chamber Various types / manufacturers	Nucletron microSeletron	Reference Air Kerma Rate (RAKR) / Apparent Activity	Ir-192	Nuclear Medicine Afterloading	service available only on request, depending on source adapter
Survey meter: Various types / manufacturers	Doserate and Dose (only γ -Radiation)	$H^*(10)$, (J_s , H_x)	Cs-137	radiation protection, stray radiation	Cs-137: Approx. 10 μ Sv/h – 100 mSv/h
			Co-60		Co-60: Approx. 1 mSv/h – 5 mSv/h

4 Calibration Order Forms

Calibration Order for **Therapy / Radiation Protection** (FB0045)

Calibration Order (for one detector)		AU-No.	
Calibration Type	<input type="checkbox"/> Factory or <input type="checkbox"/> DKD (= formal secondary standard calibration / DAkkS)		
Detector Type	Type No.	Serial No.	Name
Customer Specific Calibration	<input type="checkbox"/> S <input type="checkbox"/> G <input type="checkbox"/> P		
Display Instrument	Type No. / Serial No.		
	Mains Voltage		Mains Frequency
Check Source			
Adaptor			
Country			
Reference Temperature (according country)	<input type="checkbox"/> 20°C <input type="checkbox"/> 22 °C		
Measuring Quantity (according detector type, country, application, customer)	Absorbed Dose to Water <input type="checkbox"/> D_w Air Kerma <input type="checkbox"/> K_a Exposure <input type="checkbox"/> J_s Ambient Dose Equivalent <input type="checkbox"/> $H^*(10)$		
Radiation Quality (according detector type, application, measuring quantity, calibration type, customer requirements)			
<input type="checkbox"/> Therapy, conventional <input type="checkbox"/> ^{60}Co <input type="checkbox"/> ^{137}Cs <input type="checkbox"/> 280 kV (T280) <input type="checkbox"/> 200 kV (T200) <input type="checkbox"/> 70-280 kV * (T70-T100-T140-T200-T280) <input type="checkbox"/> 100-280 kV * (T100-T140-T200-T280) <input type="checkbox"/> 140-280 kV * (T140-T200-T280) <input type="checkbox"/> Therapy, Soft X-Ray <input type="checkbox"/> 15-70 kV (TW15-TW30-TW50-TW70)		<input type="checkbox"/> Radiation Protection <input type="checkbox"/> ^{60}Co <input type="checkbox"/> ^{137}Cs <input type="checkbox"/> X-ray 20-60 kV (N-20, N-30, N-40, N-60) <input type="checkbox"/> X-ray 60-250 kV (N-60, N-80, N-100, N-150, N-200, N-250) <input type="checkbox"/> Other	
Remarks / Questions: <input type="checkbox"/> End user address in calibration certificates and test documents required <input type="checkbox"/> Transfer of detector calibration data into electrometer/dosemeter required			
Correspondant / Customer:			

A current download version is available on the PTW website.

Calibration Order for **Diagnostic Radiology** (FB0046)

Calibration Order Diagnostic:		AU-No.	
Dosimeter / kV-Meter			
Calibration Type	<input type="checkbox"/> Factory or <input type="checkbox"/> DAkkS	<input type="checkbox"/> Legal Calibration	
Detector Type	Type / [REF] :	Serial-No. / [SN] :	Name
Display Instrument	Type / [REF] :	Serial-No. / [SN] :	
	Mains Voltage (V) :	Mains Frequency (Hz) :	
Country			
Reference Temperature	<input type="checkbox"/> 20°C <input type="checkbox"/> 22 °C		
Measuring Quantity	<input type="checkbox"/> Air Kerma K_a <input type="checkbox"/> Exposure J_e		
Radiation Quality			
<input type="checkbox"/> NOMEX Multimeter / To be filled, when position E21328 (legal calibration of MAM-Quality) is ordered		<input type="checkbox"/> NOMEX Dosimeter <input type="checkbox"/> DIADOS <input type="checkbox"/> DIADOS E <input type="checkbox"/> UNIDOS <input type="checkbox"/> UNIDOS E <input type="checkbox"/> UNIDOS ^{webline}	
<input type="checkbox"/> MAM (23 ... 35) kV ⇒ Single Qualities: <input type="checkbox"/> Mo / 30 µm Mo (RQR-M) <input type="checkbox"/> Mo / 25 µm Rh (MRV) <input type="checkbox"/> W / 0,7 mm Al (WAVa) <input type="checkbox"/> W / 50 µm Rh (WRV) <input type="checkbox"/> W / 50 µm Ag (WSV) <input type="checkbox"/> Rh / 25 µm Rh (RRV)		<input type="checkbox"/> MAM (standard), (25...45) kV <input type="checkbox"/> MAM (+2mmAl), (25...45) kV Mo / 30 µm Mo (RQR-M) Mo / 30µmMo + 2mmAl (RQA-M) Mo / 25 µm Rh (MRV) Mo / 25µmRh + 2mmAl (MRH) W / 0,7 mm Al (WAVa) W / 0,7mmAl + 2mmAl (WAHa) W / 50 µm Rh (WRV) W / 50µmRh + 2mmAl (WRH) W / 50 µm Ag (WSV) W / 50µmAg + 2mmAl (WSH) Rh / 25 µm Rh (RRV) Rh / 25µmRh + 2mmAl (RRH)	
Remarks / Questions: <input type="checkbox"/> End user address in calibration certificates and test documents required <input type="checkbox"/> Transfer of detector calibration data into electrometer/dosimeter required			
Correspondant of Customer:			

A current download version is available on the PTW website

4.1 Remarks and Explanations

Please use the non-shaded areas to specify exactly the calibration desired.

- Calibration type: The DAkkS(DKD) calibration is distinguished from the factory calibration by a more formal set of documents, stressing the DAkkS accreditation and specifically the traceability to the German National Laboratory, PTB
- The detector type is defined by the connector short sign (TM, TN, TW, TB, M, N, W, B) and the chamber's type number. In addition the name (e.g. Roos chamber) can be given.
- If the detector shall be calibrated with a specific display instrument this should be specified.
- Mains voltage and frequency of electrometers to be delivered with this detector.
- Check source and holding devices (adaptor) to be included in the calibration.
- Country where the detector is supposed to be used.
- Reference temperature (related to this country).
- The measuring quantity for the calibration; several quantities may be checked as applicable to the specific detector (e.g. a Farmer type chamber can be calibrated in absorbed dose to water and air kerma; of course this means additional cost; see price list).
- The radiation quality for the calibration is determined by the detector type, the intended use and the measuring quantity. Typical therapy calibrations would be ^{60}Co and possibly the X-ray energies from the lower end of the detectors useful range to 280 kV if the detector is intended for use with orthovoltage installations. Soft X-ray calibration is always from 15 to 70 kV.
- Diagnostic radiology calibrations can be 50 to 150 kV or the mammography qualities from 25 to 40 kV or the dental radiology qualities from 50 to 90 kV.
- Radiation protection qualities can be ^{137}Cs , ^{60}Co , the N-20 to N-40 soft X-ray series or the N-60 to N-300 orthovoltage series.
- The remarks box can be used for additional information concerning e.g. administrative details like the order numbers. If the calibration documentation is requested to be issued for the end user instead of the customer the check box should be marked and the end user address should be included.
- Detailed information about the direct correspondent in case of questions concerning the calibration is always welcome.

The PTW-Freiburg calibration laboratory hopes that using these forms will reduce problems and costs both on our customer's side and in our organization. Questions and suggestions about this form are always welcome and should be directed to Christian Pychlau, phone: (49) 761-49055-66.

5 DAkKS accreditation details

DAkKS Labor (früher DKD) / DAkKS laboratory (formerly DKD)

Als Ergebnis der DAkKS Kalibrierung wird ein Kalibrierschein ausgestellt, der auf der Grundlage multilateraler Abkommen im Rahmen der European Cooperation for Accreditation of Laboratories (EA) in vielen Staaten Europas und im Rahmen der International Laboratory Accreditation Cooperation (ILAC) weltweit anerkannt ist. Die DAkKS ist die nationale Akkreditierungsstelle und damit für alle Akkreditierungsangelegenheiten in Deutschland verantwortlich.

As a result of the DAkKS conformal calibration a calibration certificate is issued, which is recognised on the basis of multilateral agreements within the scope of the European Cooperation for Accreditation of Laboratories (EA) in many states of Europe as well within the scope of International Laboratory Accreditation Cooperation (ILAC) worldwide. The DAkKS represents the integrated German accreditation council and is therefore responsible for all national accreditation activities.

Leistungsangebot des D-K-15059-01-00

Das Kalibrierlaboratorium ist berechtigt, DAkKS-Kalibrierscheine für folgende Messgrößen auszustellen und als geringste Messunsicherheit die aufgeführten Werte anzugeben (siehe Auszug aus der Akkreditierungsurkunde unten):

Service scope D-K-15059-01-00

The calibration laboratory is entitled to issue DAkKS calibration certificates for the following measuring quantities with the shown values as the smallest measuring uncertainty (see column "kleinste angebbare Messunsicherheit" in DAkKS accreditation certificate excerpt below).

Permanent Laboratory

Measured quantity / Calibration item	Range	Measurement conditions / procedure	Best measurement capability ¹⁾	Remarks
Air kerma	5 mGy to 10 Gy 2 mGy to 10 Gy 2 mGy to 10 Gy 2 mGy to 10 Gy 3 mGy to 3 Gy 15 mGy to 5 Gy	X-ray tube voltage resp. radionuclides		The kerma rate resp. dose rate values given for gamma radiation are reference values for July 1987. These values
		15 kV to 70 kV	2,0 %	
		70 kV to 280 kV	1,6 %	
		RQR-M / RQA-M	1,9 %	
		RQR / RQA 40 kV to 150 kV	1,8 %	
		Caesium-137 Cobalt-60	1,6 % 1,2 %	
Air kerma rate	50 mGy/min to 500 mGy/min 20 mGy/min to 500 mGy/min 20 mGy/min to 500 mGy/min 20 mGy/min to 500 mGy/min 3 mGy/min to 250 mGy/min 15 mGy/min to 500 mGy/min	15 kV to 70 kV	2,0 %	change following the decay of the radionuclides Caesium-137 and Cobalt-60 and following source
		70 kV to 280 kV	1,6 %	
		RQR-M / RQA-M	1,9 %	
		RQR / RQA 40 kV to 150 kV	1,8 %	
		Caesium-137	1,6 %	
		Cobalt-60	1,2 %	
Ambient equivalent dose	0,01 mSv to 2 mSv 3 mSv to 3 Sv 15 mSv to 5 Sv	60 kV to 300 kV	3,5 %	changes.
		Caesium-137	3,5 %	
		Cobalt-60	3,5 %	
Ambient equivalent dose rate	10 µSv/min to 20 µSv/min 3 mSv/min to 250 mSv/min 15 mSv/min to 500 mSv/min	60 kV to 300 kV	3,5 %	
		Caesium-137	3,5 %	
		Cobalt-60	3,5 %	
Absorbed dose to water	10 mGy to 10 Gy 10 mGy to 10 Gy 50 mGy to 5 Gy	15 kV to 70 kV, z ₀	3,3 %	z ₀ : Phantom surface z ₅ : Phantom depth 5 cm
		100 kV to 280 kV, z ₅	3,3 %	
		Cobalt-60, z ₅	1,1 %	
Absorbed dose rate to water	50 mGy/min to 300 mGy/min 50 mGy/min to 300 mGy/min 50 mGy/min to 500 mGy/min	15 kV to 70 kV, z ₀	3,3 %	
		100 kV to 280 kV, z ₅	3,3 %	
		Cobalt-60, z ₅	1,1 %	