

# Allgemeiner Leistungsumfang Radiologische Kalibrierung

/ general scope of radiological calibration services

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# 1 General Information

## 1.1 Calibration

In metrology, calibration is the comparison of measurement values delivered by a device under test with those of a calibration standard of known accuracy. Such a standard could be another measurement device of known accuracy or a device generating the quantity to be measured (from Wikipedia). 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. It is important to establish the traceability to the physical quantity to be measured.

## 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 Dose Equivalent* ( $H^*(10)$ ), measured in air, stands for a radiation protection quantity for personal dose monitoring.

*Photon Dose Equivalent* ( $H_x$ ) - an older unit used for personal dose monitoring - is no longer available (for a simple transfer calculation of  $K_a$  towards  $H_x$  see table 1.1:  $H_x = K_a \times \text{Conv}_{K_a \rightarrow H_x}$ ).

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).

Table 1.1: Conversion factors for *air kerma* ( $K_a$ ) to *photon dose equivalent* ( $H_x$ )

radiation quality	N-20 bis N-300	<sup>137</sup> Cs	<sup>60</sup> Co
$\text{Conv}_{K_a \rightarrow H_x}$ [Sv/Gy]	1 / 0,877 (≈ 1,1402)	1 / 0,878 (≈ 1,1389)	1 / 0,879 (≈ 1,1376)

## 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).

Table 1.3: Applied dosimetry protocols

Measuring Quantity	Radiation Qualities	Dosimetry Protocol
Absorbed-Dose-To-Water, $D_w$	<sup>60</sup> 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), <sup>137</sup> Cs, <sup>60</sup> Co, radiation qualities base on ISO 4037-1:1996	ISO 4037-1

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.

## 1.4 Calibration Possibilities

Of course, regarding the precision demanded by our customers correct calibrations are of the highest importance. PTW Freiburg GmbH 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, OSLD 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 requires information on 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 all factory calibrations are traceable to national or international standards.

Radiological calibrations are done according to chapter 3 / *Type-specific calibration options* in this document. 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  $^{60}\text{Co}$ ; 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). Currently the PTB is preparing a standard covering these new mammography qualities.

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

Well-type chambers for the measurement of afterloading sources are calibrated for Nucletron microSelectron, Varian, Sauerwein (all  $^{192}\text{Ir}$ ) and BEBIG ( $^{192}\text{Ir}$  /  $^{60}\text{Co}$ ) 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 cm<sup>2</sup>

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 cm<sup>2</sup>

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

Field size: 10 x 10 cm<sup>2</sup>

## 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 $\mu$ m Mo	0.30 mm Al
RQR-M2	28	15.4	32 $\mu$ m Mo	0.33 mm Al
RQR-M3	30	15.7	32 $\mu$ m Mo	0.35 mm Al
RQR-M4	35	16.3	32 $\mu$ m Mo	0.38 mm Al

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

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

Quality	kV	keV*	Filter	HVL
MRH 25	25	19.3	25 $\mu$ m Rh + 2.0 mm Al	0.61 mm Al
MRH 28	28	19.6	25 $\mu$ m Rh + 2.0 mm Al	0.65 mm Al
MRH 30	30	19.9	25 $\mu$ m Rh + 2.0 mm Al	0.66 mm Al
MRH 35	35	20.9	25 $\mu$ 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<sub>a</sub>: 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<sub>a</sub>: 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<sub>a</sub>: 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<sub>a</sub>: 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<sub>a</sub>: 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<sub>a</sub>: 160 kV-Installation** Tungsten (W) Anode (GE160-1)

Field size: 40 x 40 cm<sup>2</sup>

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

**K<sub>a</sub>: 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<sub>a</sub>: 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<sub>a</sub>: 320 kV-Installation** Tungsten (W) Anode (GE320-1)

Field size: 10 x 10 cm<sup>2</sup>

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<sub>a</sub>: 320 kV-Installation Tungsten (W) Anode (GE320-1)**

Field size: 30 x 30 cm<sup>2</sup>

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<sub>a</sub>: 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<sub>a</sub>: 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<sub>a</sub>: 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<sub>a</sub>: 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<sub>a</sub>: Co-60 / 220 TBq (6000 Ci) (1.330 MeV)**

Field size: 10 x 10 cm<sup>2</sup>

**K<sub>a</sub>: Co-60 / 220 TBq (6000 Ci) (1.330 MeV)**

Field size: 10 x 10 cm<sup>2</sup>

## 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 cm<sup>2</sup>

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 cm<sup>2</sup>

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<sub>s</sub>)

J<sub>s</sub>: 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<sub>s</sub>: 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<sub>s</sub>: 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<sub>s</sub>: 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<sub>s</sub>: 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<sub>s</sub>: 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<sub>s</sub>: 320 kV-Installation** Tungsten (W) Anode (GE320-1)

Field size: 10 x10 cm<sup>2</sup>

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<sub>s</sub>: 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<sub>s</sub>: 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<sub>s</sub>: 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<sub>s</sub>: 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<sub>s</sub>: Co-60 / 220 TBq (6000 Ci) (1.330 MeV)**

Field size: 10 x 10 cm<sup>2</sup>

**J<sub>s</sub>: Co-60 / 220 TBq (6000 Ci) (1.330 MeV)**

Field size: 10 x 10 cm<sup>2</sup>

## 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 cm<sup>2</sup>

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 cm<sup>2</sup>

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<sub>s</sub> · L: 150 kV-Installation** Tungsten Anode (*Epsilon2*)

Field size: 8.0 cm (field length)

<b>Quality</b>	<b>kV</b>	<b>keV*</b>	<b>Filter</b>	<b>HVL</b>
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 cm<sup>2</sup>

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

### H\*(10): 320 kV-Installation Tungsten (W) Anode (GE320-1)

Field size: 30 x 30 cm<sup>2</sup>

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

### 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
<b>Ion Chamber</b> C-chamber 0.1 cm <sup>3</sup> 23322	<sup>60</sup> Co	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
	<sup>137</sup> Cs	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			<sup>137</sup> Cs-installation 5,5 TBq (150 Ci)
	200 kV - 280 kV	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			320 kV-installation tungsten anode
<b>Ion Chamber</b> micro chamber 0.1 cm <sup>3</sup> 2332, 23323	<sup>60</sup> Co	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
	<sup>137</sup> Cs	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			<sup>137</sup> Cs-installation 5,5 TBq (150 Ci)
	140 kV - 280 kV	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			320 kV-installation tungsten anode
<b>Ion Chamber</b> compact chamber 1 cm <sup>3</sup> rigid 23331 and 30015	<sup>60</sup> Co	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
	<sup>137</sup> Cs	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			<sup>137</sup> Cs-installation 5,5 TBq (150 Ci)
	100 kV - 280 kV 70 kV - 280 kV	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			320 kV-installation tungsten anode
	40 kV - 150 kV	K <sub>a</sub> , J <sub>s</sub>		Diagnostic Radiology	160 kV-installation tungsten anode
<b>Ion Chamber</b> compact chamber 0.3 cm <sup>3</sup> rigid 23332 and 30016	<sup>60</sup> Co	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
	<sup>137</sup> Cs	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			<sup>137</sup> Cs-installation 5,5 TBq (150 Ci)
	140 kV - 280 kV	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			320 kV-installation tungsten anode
	50 kV - 150 kV (RQR / RQA)	K <sub>a</sub> , J <sub>s</sub>		Diagnostic Radiology	160 kV-installation tungsten anode
<b>Ion Chamber</b> soft X-ray 0.02 cm <sup>3</sup> 23342	15 kV - 70 kV	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub> , 15 kV - 70 kV	Radiation Therapy soft X-rays	160 kV-installation tungsten anode
					320 kV-installation tungsten anode
<b>Ion Chamber</b> "Markus" chamber 0.055 cm <sup>3</sup> 23343	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
<b>Ion Chamber</b> soft X-ray 0.2 cm <sup>3</sup> 23344	15 kV - 70 kV	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub> , 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
<b>Ion Chamber</b> compact chamber 30 cm <sup>3</sup> 23361	<sup>60</sup> Co	K <sub>a</sub> , J <sub>s</sub> H*(10)	H*(10), <sup>60</sup> Co	radiation protection stray radiation	<sup>60</sup> Co-installation 35 GBq (0,95 Ci)
	<sup>137</sup> Cs	K <sub>a</sub> , J <sub>s</sub> H*(10)			<sup>137</sup> Cs-installation 50 GBq (1,35 Ci)
	20 kV - 60 kV	K <sub>a</sub> , J <sub>s</sub> H*(10)			160 kV-installation tungsten anode
	60 kV - 250 kV	K <sub>a</sub> , J <sub>s</sub> H*(10)			320 kV-installation tungsten anode
	50 kV - 150 kV (RQR /RQA acc. IEC 61267)	K <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub>	Diagnostic Radiology	150 kV-installation tungsten anode 160 kV-installation tungsten anode
<b>Ion Chamber</b> parallel plate chamber 30 cm <sup>3</sup> 233612	50 kV - 150 kV (RQR /RQA acc. IEC 61267)	K <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub>	Diagnostic Radiology	150 kV-installation tungsten anode 160 kV-installation tungsten anode
<b>Ion Chamber</b> 0.3 cm <sup>3</sup> flex 233641, 31003, 31013	<sup>60</sup> Co	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
	<sup>137</sup> Cs	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			<sup>137</sup> Cs-installation 5,5 TBq (150 Ci)
	140 kV - 280 kV	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			320 kV-installation tungsten anode
<b>Ion Chamber</b> 0.125 cm <sup>3</sup> flex 233642, 31002, 31010	<sup>60</sup> Co	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
	<sup>137</sup> Cs	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			<sup>137</sup> Cs-installation 5,5 TBq (150 Ci)
	140 kV - 280 kV	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			320 kV-installation tungsten anode
<b>Ion Chamber</b> „Farmer“ chambers 0.6 cm <sup>3</sup> 30001, 30006, 30010, 30013	<sup>60</sup> Co	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
	<sup>137</sup> Cs	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			<sup>137</sup> Cs-installation 5,5 TBq (150 Ci)
	100 kV - 280 kV 70 kV - 280 kV	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			320 kV-installation tungsten anode
<b>Ion Chamber</b> „Farmer“ chambers graphite, 0.6 cm <sup>3</sup> 30002, 30004, 30005, 30011, 30012	<sup>60</sup> Co	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
	<sup>137</sup> Cs	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			<sup>137</sup> Cs-installation 5,5 TBq (150 Ci)
	100 kV - 280 kV 70 kV - 280 kV	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>			320 kV-installation tungsten anode
<b>Ion Chamber</b> PinPoint chamber 0.015/0.016/0.03 cm <sup>3</sup> 31006, 31009, 31014, 31015, 31016, 31022, 31023	Co-60	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
<b>Ion Chamber</b> 0.07 cm <sup>3</sup> semiflex 3D 31021	Co-60	D <sub>w</sub> K <sub>a</sub> , J <sub>s</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)

Chamber Type	Tube Voltage / Isotope	Possible Measuring Quantities	Typical Calibration Points	Range of Use	Remarks
<b>Ion Chamber</b> 100 cm <sup>3</sup> chamber 32001	<sup>137</sup> Cs	K <sub>a</sub> , J <sub>s</sub> , H*(10)	H*(10), <sup>137</sup> Cs	radiation protection	<sup>137</sup> Cs-installation 50 GBq (1,35 Ci)
<b>Ion Chamber</b> spherical chamber 1 l 32002	<sup>137</sup> Cs	K <sub>a</sub> , J <sub>s</sub> , H*(10)	H*(10), <sup>137</sup> Cs	radiation protection stray radiation	<sup>137</sup> Cs-installation 50 GBq (1,35 Ci)
	N20 – N40	K <sub>a</sub> , H*(10)			160 kV-installation tungsten anode
	N60 - N250	K <sub>a</sub> , H*(10)			320 kV-installation tungsten anode
	<sup>60</sup> Co	K <sub>a</sub> , J <sub>s</sub> , H*(10)	H*(10), <sup>60</sup> Co		<sup>60</sup> Co-installation 35 GBq (0,95 Ci)
<b>Ion Chamber</b> spherical chamber 10 l 32003	<sup>137</sup> Cs	K <sub>a</sub> , J <sub>s</sub> , H*(10)	H*(10), <sup>137</sup> Cs	radiation protection stray radiation	<sup>137</sup> Cs-installation 50 GBq (1,35 Ci)
	N20 – N40	K <sub>a</sub> , H*(10)			160 kV-installation tungsten anode
	N60 - N250	K <sub>a</sub> , H*(10)			320 kV-installation tungsten anode
	<sup>60</sup> Co	K <sub>a</sub> , J <sub>s</sub> , H*(10)	H*(10), <sup>60</sup> Co		<sup>60</sup> Co-installation 35 GBq (0,95 Ci)
<b>Ion Chamber</b> spherical chamber 30 cm <sup>3</sup> 32005	<sup>137</sup> Cs	K <sub>a</sub> , J <sub>s</sub> , H*(10)	H*(10), <sup>137</sup> Cs	radiation protection stray radiation	<sup>137</sup> Cs-installation 50 GBq (1,35 Ci)
	N20 – N40	K <sub>a</sub> , H*(10)			160 kV-installation tungsten anode
	N60 - N250	K <sub>a</sub> , H*(10)			320 kV-installation tungsten anode
	<sup>60</sup> Co	K <sub>a</sub> , J <sub>s</sub> , H*(10)	H*(10), <sup>60</sup> Co		<sup>60</sup> Co-installation 35 GBq (0,95 Ci)
	50 kV - 150 kV (RQR /RQA acc. IEC 61267)	K <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub>	Diagnostic Radiology	160 kV-installation tungsten anode
<b>Ion Chamber</b> spherical chamber 3 l 32006	<sup>137</sup> Cs	K <sub>a</sub> , J <sub>s</sub> , H*(10)	H*(10), <sup>137</sup> Cs	radiation protection stray radiation	<sup>137</sup> Cs-installation 50 GBq (1,35 Ci)
	<sup>60</sup> Co	K <sub>a</sub> , J <sub>s</sub> , H*(10)	H*(10), <sup>60</sup> Co		<sup>60</sup> Co-installation 35 GBq (0,95 Ci)
<b>Ion Chamber</b> Neutron Chamber (Kühn) 33051, 33052, 33053, 33054	<sup>60</sup> Co	K <sub>a</sub>	K <sub>a</sub> , <sup>60</sup> Co		<sup>60</sup> Co-installation 220 TBq (6000 Ci) <b>Test Certificate only</b>
<b>Ion Chamber</b> „Roos“ chamber 0.35 cm <sup>3</sup> 34001	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
<b>Ion Chamber</b> soft X-ray 0.005 cm <sup>3</sup> 34013	15 kV - 70 kV	D <sub>w</sub>	K <sub>a</sub> 15 kV - 70 kV	Radiation Therapy soft X-rays	160 kV-installation tungsten anode
		K <sub>a</sub> , J <sub>s</sub>			320 kV-installation tungsten anode

Chamber Type	Tube Voltage / Isotope	Possible Measuring Quantities	Typical Calibration Points	Range of Use	Remarks
<b>Ion Chamber</b> Diamentor chambers 34037	only 70 kV	K <sub>a</sub>		Diamentor	300 kV-installation tungsten anode
<b>Ion Chamber</b> „Advanced Markus“ chamber 34045	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
<b>Ion Chamber</b> SFD chamber 75 cm <sup>3</sup> 34060	50 kV - 150 kV (RQR /RQA acc. IEC 61267)	K <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub> / RQR <sup>(1)</sup>	Diagnostic Radiology	150 kV-installation tungsten anode
					160 kV-installation tungsten anode
<b>Ion Chamber</b> SFD mammography chamber 6 cm <sup>3</sup> 34069	50 kV - 150 kV (RQR /RQA acc. IEC 61267)	K <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub> / RQR <sup>(1)</sup>	Diagnostic Radiology	150 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 <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub> / RQR-M <sup>(2)</sup>	Mammography	35 kV-installation Mo/W anode
					49 kV-installation W anode
25 kV - 35 kV (RQA-M acc. IEC 61267, MRH, WAHa, WRH, WSH acc. PTB)				49 kV-installation Rh/Mo anode	
25 kV - 35 kV RRV/RRH acc.PTB				49 kV-installation Rh/Mo anode	
<b>Ion Chamber</b> Bragg-Peak chamber 34070, 34073, 34080	<sup>60</sup> Co	K <sub>a</sub>			<sup>60</sup> Co-installation 220 TBq (6000 Ci) <b>Test Certificate only</b>
<b>Ion Chamber</b> 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 <sub>a</sub> · area J <sub>s</sub> · area DAP	K <sub>a</sub> · area	Diamentor	300 kV-installation tungsten anode
	50 kV - 150 kV (RQR acc. IEC 61267)	K <sub>a</sub> · area J <sub>s</sub> · area DAP	K <sub>a</sub> · area		160 kV-installation tungsten anode
<b>Ion Chamber</b> Diamentor chambers 57554, 34002, 34011, 34052, 34054	40 kV - 150 kV RQR-qualities	K <sub>a</sub> · area J <sub>s</sub> · area	K <sub>a</sub> · area DAP	Diamentor	300 kV-installation tungsten anode
	40 kV - 150 kV RQR-qualities	K <sub>a</sub> · area J <sub>s</sub> · area			160 kV-installation tungsten anode
<b>Ion Chamber</b> Parallel plate chamber 112 cm <sup>3</sup> 77335 and 7733	50 kV - 150 kV (RQR /RQA acc. IEC 61267)	K <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub>	Diagnostic Radiology	150 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
<b>Ion Chamber</b> Parallel plate chamber 1 cm <sup>3</sup> 77334, 77337	50 kV - 150 kV (RQR acc. IEC 61267)	K <sub>a</sub> , J <sub>s</sub>		Diagnostic Radiology	150 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 <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub>	Mammography	35 kV-installation Mo/W anode
	25 kV - 35 kV RRV/RRH acc. PTB				49 kV-installation Rh/Mo anode
<b>Ion Chamber</b> CT-chamber 77336, 30009, 30017	100 kV - 150 kV (RQT acc. IEC 61267)	K <sub>a</sub> · length J <sub>s</sub> · length DLP	K <sub>a</sub> · length, RQT 9	Diagnostic Radiology	160 kV-installation tungsten anode
<b>Ion Chamber</b> cylindrical chamber 50 l 7262	<sup>137</sup> Cs	K <sub>a</sub> , J <sub>s</sub> , H*(10)	H*(10), <sup>137</sup> Cs	radiation protection stray radiation	<sup>137</sup> Cs-installation 50 GBq (1,35 Ci)
	<sup>60</sup> Co	K <sub>a</sub> , J <sub>s</sub> , H*(10)	H*(10), <sup>60</sup> Co		<sup>60</sup> Co-installation 35 GBq (0,95 Ci)
<b>Diamond</b> 60003	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
<b>Diode</b> Diados detector Type: 60004	50 kV - 150 kV (RQR /RQA )	K <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub> / RQR <sup>(1)</sup>	Diagnostic Radiology	160 kV-installation tungsten anode
	50 kV - 90 kV (RQR / RQA acc. IEC 61267)	K <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub>	Dental	160 kV-installation tungsten anode
<b>Diode</b> 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 <sub>a</sub> , J <sub>s</sub>	K <sub>a</sub> / RQR-M <sup>(2)</sup>	Diagnostic Radiology Mammography	35 kV-installation Mo/W anode
<b>Diode</b> dosimetry diode (E) 60008 / 60012	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
<b>microDiamond</b> 60019	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
<b>QC6Plus</b> 42007	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
<b>QUICKCHECKweblin</b> 42031	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> 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	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
2D-Array 729 XDR 10031	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Protons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
STARCHECK (MR) 10032 / 10043	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
STARCHECKmaxi (MRI) 10033 / 10049	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
OCTAVIUS 1000 SRS 10036	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
OCTAVIUS 729 (XDR) 10040 / 10042	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
OCTAVIUS 1500 (XDR) 10044 / 10051	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
OCTAVIUS 1500 MRI 10050	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
LA 48 34009	<sup>60</sup> Co	D <sub>w</sub>	D <sub>w</sub> , <sup>60</sup> Co	Radiation Therapy Photons/Electrons	<sup>60</sup> Co-installation 220 TBq (6000 Ci)
Diamentor C02, C02H Types: 11018 und 11044	40 kV - 120 kV (RQR /IEC61267)	K <sub>a</sub> · area DAP	K <sub>a</sub> · 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 <sub>a</sub> · area DAP	K <sub>a</sub> · 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 <sub>a</sub> · area DAP	K <sub>a</sub> · 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 acc. IEC 61267)	K <sub>a</sub>	K <sub>a</sub>	Diagnostic Radiology	160 kV-installation tungsten anode
	25 kV - 35 kV (RQR-Mx acc. IEC 61267)	K <sub>a</sub>	K <sub>a</sub>	Mammography	160 kV-installation tungsten anode

Chamber Type	Possible Calibrations	Measuring Quantities	Isotope	Range of Use	Remarks
<b>SourceCheck 4Pi</b> 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
<b>SourceCheck 4Pi</b> 33005 <i>HDR</i>	Nucletron microSelectron® / microSelectron V2®	RAKR / Apparent Activity	Ir-192	Nuclear Medicine Afterloading	Supported adapters: <ul style="list-style-type: none"> <li>T33002.1.009</li> <li>T33004.1.011</li> <li>T33004.1.012</li> <li>T33004.1.013</li> </ul>
	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"> <li>11-00207 3 mm Ø steel applicator</li> <li>4.7Fr VariSource Plastic Tipped Catheter</li> <li>LAA 1400-GYN Ø 3mm</li> <li>Varian GM11002070 Ø 3 mm</li> <li>Steel needle Ø 1.7 mm</li> </ul>
	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	
<b>SourceCheck</b> 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
<b>SourceCheck</b> 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
<b>HDR-Chamber</b> 33004	Nucletron microSelectron® / microSelectron V2®	RAKR / Apparent Activity	Ir-192	Nuclear Medicine Afterloading	Supported adapters: <ul style="list-style-type: none"> <li>T33002.1.009</li> <li>T33004.1.011</li> <li>T33004.1.012</li> <li>T33004.1.013</li> </ul> Supported applicators: <ul style="list-style-type: none"> <li>11-00207 3 mm Ø steel applicator</li> <li>4.7Fr VariSource Plastic Tipped Catheter</li> <li>LAA 1400-GYN Ø 3mm</li> <li>Varian GM11002070 Ø 3 mm</li> <li>Steel needle Ø 1.7 mm</li> </ul>
	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	
<b>HDR-Chamber</b> 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
<b>HDR-Chamber</b> 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
<b>Survey meter:</b> Various types / manufacturers	Doserate and Dose (only $\gamma$ -Radiation)	$H^*(10)$ , ( $J_s$ , $H_x$ )	Cs-137	radiation protection, stray radiation	Cs-137: Approx. 10 $\mu$ 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)

<b>Calibration Order</b> (for one detector)		<b>AU-No.</b>	
Calibration Type	<input type="checkbox"/> Factory or <input type="checkbox"/> DKD (= formal secondary standard calibration / DAkkS)		
optional: <input type="checkbox"/> MR safety certificate			
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 <sub>w</sub> Air Kerma <input type="checkbox"/> K <sub>a</sub> Exposure <input type="checkbox"/> J <sub>s</sub>		
	Ambient Dose Equivalent <input type="checkbox"/> H*(10) <input type="checkbox"/> D <sub>w</sub> /K <sub>a</sub> bundle		
Radiation Quality (according detector type, application, measuring quantity, calibration type, customer requirements)			
<input type="checkbox"/> Therapy, conventional <input type="checkbox"/> <sup>60</sup> Co <input type="checkbox"/> <sup>137</sup> 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"/> <sup>60</sup> Co <input type="checkbox"/> <sup>137</sup> 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	
*) T70 not available for D <sub>w</sub> , KV-range depends on detector type / current T-quality labelling is e.g.: T200 equals TH 200			
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:			
Auftrag erstellt am:		von:	
Auftrag erledigt am:		von:	

Document: Revision 007/02.2021 Dok.Nr. PTW-000102 Titel: FB0045e Kalibrierauftrag englisch

A current version of this form is available for download on the PTW website.



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

<b>Calibration Order Diagnostic:</b>		<b>AU-No.</b>	
<b>Dosimeter / kV-Meter</b>			
Calibration Type	<input type="checkbox"/> Factory or <input type="checkbox"/> DAkkS (acc. ISO 17025 / formerly DKD)		<input type="checkbox"/> Legal Calibration <sup>1)</sup>
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 <sub>a</sub> <input type="checkbox"/> Exposure J <sub>s</sub>		
<b>Radiation Quality</b>			
<b>NOMEX Multimeter</b>		<input type="checkbox"/> NOMEX Dosemeter <sup>1)</sup> <input type="checkbox"/> DIADOS <input type="checkbox"/> DIADOS E	
Calibration:		<input type="checkbox"/> UNIDOS <input type="checkbox"/> UNIDOS E <input type="checkbox"/> UNIDOS <sup>webline</sup>	
<input type="checkbox"/> R/F or IGRT	Legal Cal. <sup>1)</sup> : <input type="checkbox"/>	<input type="checkbox"/> RAD/FLU, (40 ... 150) kV, RQR 3/5/7/9/10 + RQA 3/5/7/9/10	
<input type="checkbox"/> DENT / DENT-PAN	<input type="checkbox"/>	<input type="checkbox"/> Dental, (50 ... 90) kV, DT 50/70/90 + DTCu50/70/90	
<input type="checkbox"/> CT	<input type="checkbox"/>	<input type="checkbox"/> CT (Standard), (100 ... 150) kV, RQT 8/9/10	
<input type="checkbox"/> MAM (20...49) kV <sup>2)</sup> , Standard:	Legal Cal. <sup>3)</sup> : <input type="checkbox"/>	<input type="checkbox"/> CT (Non-Std.), (70 ... 150) kV, RQR 5/7/9/10 + RQA 5/7/9/10	
<u>including</u>		<input type="checkbox"/> MAM (Standard), (20...49) <sup>2)</sup> kV: <input type="checkbox"/> MAM (Standard) + 2 mm Al:	
Mo / 30 µm Mo (RQR-M)	<input type="checkbox"/>	<u>including</u>	<u>including</u>
Mo / 25 µm Rh (MRV) <sup>3)</sup>	<input type="checkbox"/>	Mo / 30 µm Mo (RQR-M)	RQR-M + 2 mm Al (RQA-M)
W / 0.7 mm Al (WAVa) <sup>3)</sup>	<input type="checkbox"/>	Mo / 25 µm Rh (MRV) <sup>3)</sup>	MRV + 2 mm Al (MRH) <sup>3)</sup>
W / 50 µm Rh (WRV) <sup>3)</sup>	<input type="checkbox"/>	W / 0.7 mm Al (WAVa) <sup>3)</sup>	WAVa + 2 mm Al (WAHa) <sup>3)</sup>
W / 50 µm Ag (WSV) <sup>3)</sup>	<input type="checkbox"/>	W / 50 µm Rh (WRV) <sup>3)</sup>	WRV + 2 mm Al (WRH) <sup>3)</sup>
Rh / 25 µm Rh (RRV) <sup>3)</sup>	<input type="checkbox"/>	W / 50 µm Ag (WSV) <sup>3)</sup>	WSV + 2 mm Al (WSH) <sup>3)</sup>
		Rh / 25 µm Rh (RRV) <sup>3)</sup>	RRV + 2 mm Al (RRH) <sup>3)</sup>
<input type="checkbox"/> MAM (20...49) kV <sup>2)</sup> Special <sup>4)</sup> :		<input type="checkbox"/> MAM (20...49) kV <sup>2)</sup> Special <sup>4)</sup> :	
<input type="checkbox"/> W / 0.3 mm Cu (WCV) <sup>3)</sup>		<input type="checkbox"/> W / 0.3 mm Cu (WCV) <sup>3)</sup>	
<input type="checkbox"/> W / 1.1 mm Ti (WTV) <sup>3)</sup>		<input type="checkbox"/> W / 1.1 mm Ti (WTV) <sup>3)</sup>	
<input type="checkbox"/> Mo / 0.25 mm Cu (MCV) <sup>3)</sup>		<input type="checkbox"/> Mo / 0.25 mm Cu (MCV) <sup>3)</sup>	
<input type="checkbox"/> Rh / 30 µm Ag (RSV) <sup>3)</sup>		<input type="checkbox"/> Rh / 30 µm Ag (RSV) <sup>3)</sup>	
<input type="checkbox"/> Rh / 0.25 mm Cu (RCV) <sup>3)</sup>		<input type="checkbox"/> Rh / 0.25 mm Cu (RCV) <sup>3)</sup>	
<sup>1)</sup> Customer information → only required in Germany <sup>2)</sup> The covered kV range depends on the respective MAM radiation quality.			
<sup>3)</sup> MAM radiation qualities according to PTB definition. <sup>4)</sup> Special = special execution calibration.			
<sup>5)</sup> Legal calibrations are available in the range of (23 ... 35) kV only			
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:			
Auftrag erstellt am:		von:	
Auftrag erledigt am:		von:	

A current version of this form is available for download 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 according the ISO 17025 and specifically the traceability to the German National Laboratory, PTB.
- The detector type is defined by the connector short sign (TM, TN, TW, TB, TL, 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  $^{60}\text{Co}$  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 (ISO4037-1) can be  $^{137}\text{Cs}$ ,  $^{60}\text{Co}$  or the N-series from N-20 to N-300.
- 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 respective 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 Matthias Rateitzak, phone: (49) 761-49055-830.

## 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 Muster-Auszug aus der Akkreditierungsurkunde unten).

Die aktuell gültige Version steht zum Herunterladen bereit unter:

[https://www.ptwdosimetry.com/fileadmin/user\\_upload/Downloads/Calibrations/D-K-15059-01-00.pdf](https://www.ptwdosimetry.com/fileadmin/user_upload/Downloads/Calibrations/D-K-15059-01-00.pdf)

### 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 sample excerpt below).*

The current version is available for download at:

[https://www.ptwdosimetry.com/fileadmin/user\\_upload/Downloads/Calibrations/D-K-15059-01-00e.pdf](https://www.ptwdosimetry.com/fileadmin/user_upload/Downloads/Calibrations/D-K-15059-01-00e.pdf)

Permanent Laboratory						
Measurement quantity / Calibration item	Range		Measurement conditions / procedure		Expanded uncertainty of measurement <sup>1)</sup>	Remarks
<b>Dosimetry</b> Air kerma	5 mGy	to 10 Gy	X-ray tube voltage, radionuclide resp. radiation quality 15 kV to 70 kV 70 kV to 280 kV 20 kV to 50 kV (Mammography) 40 kV to 150 kV (RAD) <sup>137</sup> Cs <sup>60</sup> Co	2.0 %	During gamma radiation indicated dose rates are indications for July 1987, May 2008 and/or April 2014 according to the assigned sources. These are reduced in consequence of the source strength decrease with the appropriate radioactive half-lives and increased if necessary with source change. z <sub>1</sub> : Phantom surface z <sub>2</sub> : Phantom depth 5 cm	
	2 mGy	to 10 Gy		1.9 %		
	100 µGy	to 10 mGy		2.5 %		
	100 µGy	to 100 mGy		2.5 %		
	1 µGy	to 3 Gy		1.9 %		
2 µGy	to 5 Gy	1.2 %				
Air kerma rate	50 mGy/min	to 500 mGy/min	15 kV to 70 kV	2.0 %		
	20 mGy/min	to 500 mGy/min	70 kV to 280 kV	1.9 %		
	200 µGy/s	to 50 mGy/s	20 kV to 50 kV (Mammography)	2.5 %		
	5 µGy/s	to 50 mGy/s	40 kV to 150 kV (RAD)	2.5 %		
	500 µGy/h	to 250 mGy/min	<sup>137</sup> Cs	1.9 %		
1 mGy/h	to 500 mGy/min	<sup>60</sup> Co	1.2 %			
Ambient equivalent dose	10 µSv	to 2 mSv	30 kV to 300 kV	3.6 %		
	3 mSv	to 3 Sv	<sup>137</sup> Cs	4.6 %		
	2 µSv	to 5 Sv	<sup>60</sup> Co	4.4 %		
Ambient equivalent dose rate	1 mSv/h	to 400 mSv/h	30 kV to 300 kV	3.6 %		
	25 mSv/h	to 400 mSv/h	<sup>137</sup> Cs	4.6 %		
	350 µSv/h	to 5 mSv/h	<sup>137</sup> Cs	5.3 %		
	0.5 µSv/h	to 10 µSv/h	<sup>137</sup> Cs	7.5 %		
	500 µSv/h	to 12 mSv/h	<sup>60</sup> Co	4.4 %		
Air kerma length product	700 µGy · cm	to 700 mGy · cm	70 kV to 150 kV	2.7 %		
Air kerma length product rate	35 µGy · cm/s	to 350 mGy · cm/s	70 kV to 150 kV	2.7 %		
Absorbed dose to water	10 mGy	to 10 Gy	10 kV to 100 kV, z <sub>0</sub>	3.4 %		
	10 mGy	to 10 Gy	100 kV to 280 kV, z <sub>0</sub>	2.9 %		
	50 mGy	to 5 Gy	<sup>60</sup> Co, z <sub>0</sub>	1.1 %		
Absorbed dose rate to water	50 mGy/min	to 300 mGy/min	10 kV to 100 kV, z <sub>0</sub>	3.4 %		
	50 mGy/min	to 300 mGy/min	100 kV to 280 kV, z <sub>0</sub>	2.9 %		
	50 mGy/min	to 300 mGy/min	<sup>60</sup> Co, z <sub>0</sub>	1.1 %		
	> 40 kV	to 150 kV		1.2 %		

<sup>1)</sup> The expanded uncertainties according to EA-4/02 M:2013 are part of CMC and are the best measurement uncertainties within accreditation. They have a coverage probability of approximately 95 % and have a coverage factor of k = 2 unless stated otherwise. Uncertainties without unit are relative uncertainties referring to the measurement value unless stated otherwise.



Annex to the accreditation certificate D-K-15059-01-00

Permanent Laboratory						
Measurement quantity / Calibration item	Range		Measurement conditions / procedure		Expanded uncertainty of measurement <sup>1)</sup>	Remarks
DC-voltage	20 kV	bis 40 kV	IEC 61876:2002	1.4 %	For in-house calibration of non-invasive measurement-gadgets	
	>40 kV	bis 150 kV		1.2 %		

#### Abbreviations used:

CMC Calibration and measurement capabilities (Kalibrier- und Messmöglichkeiten)  
IEC International Electrotechnical Commission