SH:n annosmittausohjeen päivitys

SH-fyysikoiden 39. neuvottelupäivät
6.-7.6.2024, Katajanokan Kasino

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Kansallinen sädehoidon annosmittausohje STUK (2005)

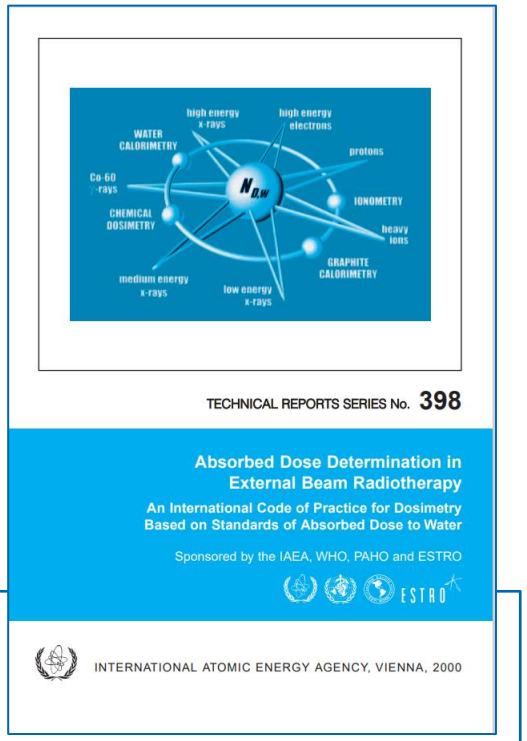
Kansainväliseen ohjeistukseen (IAEA TRS398) pohjautuva kansallinen ulkoisen sädehoidon annosmittausohje.

- **Lineaarikiihdyttimien WFF fotoni- ja elektronikeilat**
- **Suureena veteen absorboitunut annos D_w**
- **Mittaukset ^{60}Co-keilassa kalibroiduilla ion.kammioilla vedessä**

$$N_{Dw,Co60} * k_{Q,Qo} = N_{Dw,Q} \quad (^{60}Co \rightarrow MV)$$

→ **Kiihdyttimen annosmonitorin kalibrointi referenssigeometriassa**

- **Menetelmät**
- **Laitteisto**



STUK

SÄDEHOIDON ANNOSMITTAUKSET

STUK-STO-TR 1 / HELMIKUU 2005

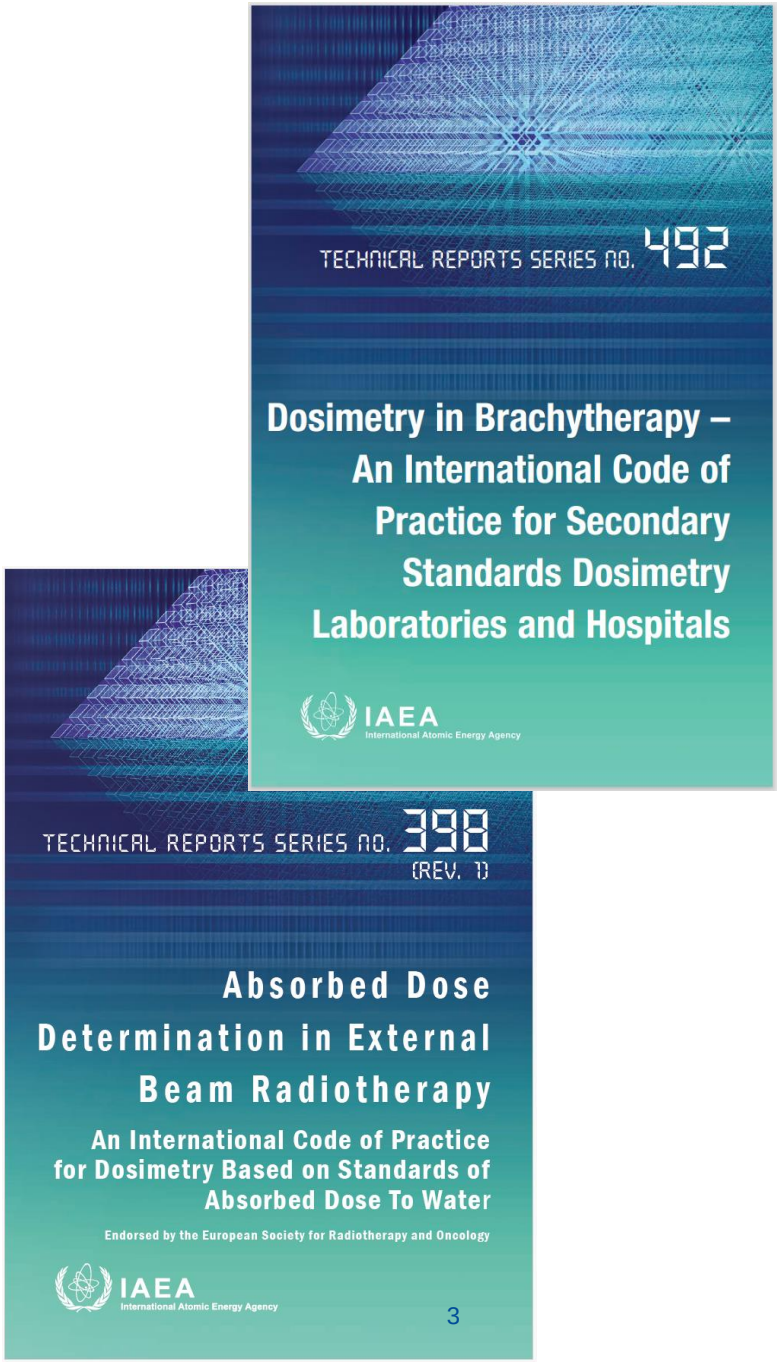
Ulkoisen sädehoidon suurenergisten fotoni- ja elektronisäteilykeilojen kalibrointi

Antti Kosunen, Petri Sipilä, Ritva Parkkinen, Ilkka Jokelainen, Hannu Järvinen

Uudet laitteet – uudet ohjeet

Kansainvälisen ohjeistuksen uudistuksen myötä - kansallisen annosmittausohjeen päivitys ja täydennys ~~2023~~ 2024 aikana 😕

- **TRS492 (December 2023) - Sisäisen sädehoidon dosimetria**
  - **HDR ^{192}Ir –lähteet + kaivokammio (K_R -> A)**
  - Dosimetry in Brachytherapy – An International Code of Practice for Secondary Standards Dosimetry Laboratories and Hospitals | IAEA
  - **Sairaaloiden nykyinen käytäntö protokollan mukainen!**
- **TRS398 (Rev 1, February 2024) - Ulkoiset MV fotoni- ja elektronikeilat**
  - Absorbed Dose Determination in External Beam Radiotherapy | IAEA



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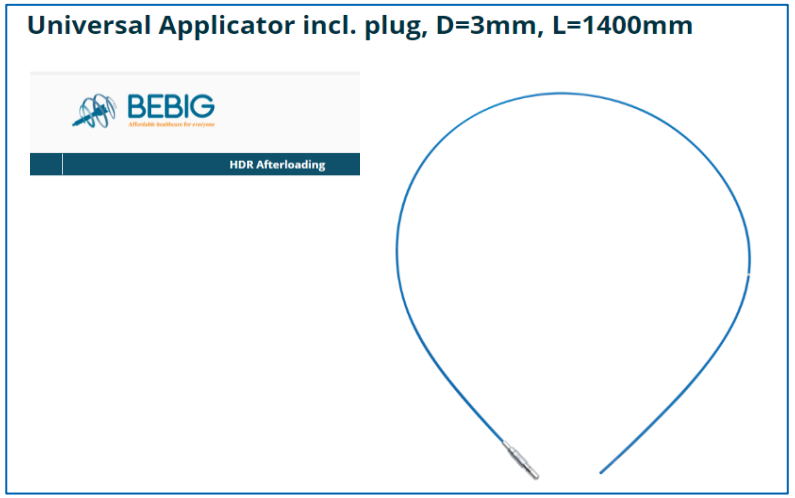
SÄTEILYTURVAKESKUS
STRÅLSÄKERHETSCENTRALEN
RADIATION AND NUCLEAR SAFETY AUTHORITY

Eri kammio-tyyppejä Suomessa

- PTW33005
  - Useita adaptereita eri katetreille
- SI HDR 1000 Plus
  - Useita adaptereita eri katetreille

Eri katetri-tyyppejä

- LAA 1400-GYN Ø 3 mm (löytyy)
- Varian GM11002070 ø 3 mm (löytyy)
- 4.7Fr VariSource Plastic Tipped Catheter (??)
- Steel needle ø 1.7 mm (??)



Kaivokammioiden kalibroinnit

Kalibrointeja

- ❑ eri lähde-tyypeille
- ❑ eri adapteri-tyypeille
- ❑ eri aplikaattori-tyypeille

Reference Air Kerma Rate	$N_{RAKR} = 9.192 \cdot 10^{5}$ Gy m^2 h^{-1} A^{-1}
Apparent Activity	$N_{AA} = 8.356 \cdot 10^{18}$ Bq A^{-1} or $N_{AA} = 2.258 \cdot 10^{8}$ Ci A^{-1}

Source Type Correction Table

Isotope	Source Type	Correction Factor (k_{Source})
^{192}Ir	Eckert&Ziegler BEBIG Ir2.A85-2	1.0000
^{192}Ir	MDS Nordion GammaMed / Varian GammaMedPlus	0.9961
^{192}Ir	Varian Varisource	0.9829
^{60}Co	Nucletron Flexisource Co60	1.0330
^{60}Co	Eckert&Ziegler BEBIG Co0.A86 / Eckert&Ziegler BEBIG GK60M21	1.0340

Source type correction according: $N_{Source} = N_{RAKR} \times k_{Source}$

Adapter/Applicator Correction

Adapter	Applicator	$k_{Applicator}(^{192}Ir)$	$k_{Applicator}(^{60}Co)$
T33002.1.009	-	1.000	1.000
T33004.1.013	LAA 1400-GYN ∅ 3 mm	1.019	1.024
T33004.1.012	4.7Fr VariSource Plastic Tipped Catheter	1.019	1.024
T33004.1.013	Varian GM11002070 ∅ 3 mm	1.029	1.027
T33004.1.013	11-00207 3 mm ∅ steel applicator	1.029	1,027
-	Steel needle ∅ 1.7 mm	0.986	0.976

Adapter/Applicator correction according: $N_{Appl} = N_{Source} \times k_{Applicator}$

IAEA TRS492

Korjauskertoimet eri lähde-tyypeille

- ❑ vain SI HDR Plus – kammiolle!!
- ❑ vain yhdelle holderille
- ❑ Mille katetrille??

TABLE 8. SOURCE MODEL CORRECTION FACTORS, k_{sm,sm_0}, FOR DIFFERENT TYPES OF HDR AND PDR ^{192}IR SOURCES FOR USE WITH A STANDARD IMAGING HDR 1000 PLUS WELL-TYPE CHAMBER WITH HDR IRIDIUM SOURCE HOLDER MODEL 70010, BASED ON MONTE CARLO CALCULATED CORRECTION FACTORS FROM [157] WITH AN EXPANDED UNCERTAINTY OF 0.4% ($k = 2$).

sm \ sm_0	Elekta Flexisource HDR Ir-192	Elekta microSelectron mHDR-v1 (classic)	Elekta microSelectron mHDR-v2	BEBIG HDR Ir-192 GI192 M11	Varian GammaMed Plus HDR	Varian VariSource VS2000	Varian GammaMed Plus PDR[a]
Elekta Flexisource HDR Ir-192	**1.000**	0.996	0.996	0.997	0.999	1.013	1.043
Elekta microSelectron mHDR-v1 (classic)	1.004	**1.000**	1.001	1.001	1.004	1.018	1.047
Elekta microSelectron mHDR-v2	1.004	0.999	**1.000**	1.001	1.003	1.017	1.047
BEBIG HDR Ir-192 GI192M11	1.003	0.999	0.999	**1.000**	1.002	1.016	1.046
Varian GammaMed Plus HDR	1.001	0.996	0.997	0.998	**1.000**	1.014	1.043
Varian VariSource VS2000	0.987	0.983	0.983	0.984	0.986	**1.000**	1.029
Varian GammaMed Plus PDR[a]	0.959	0.955	0.955	0.956	0.958	0.972	**1.000**

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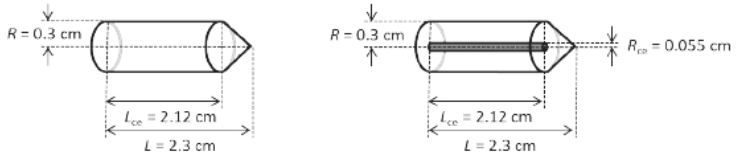
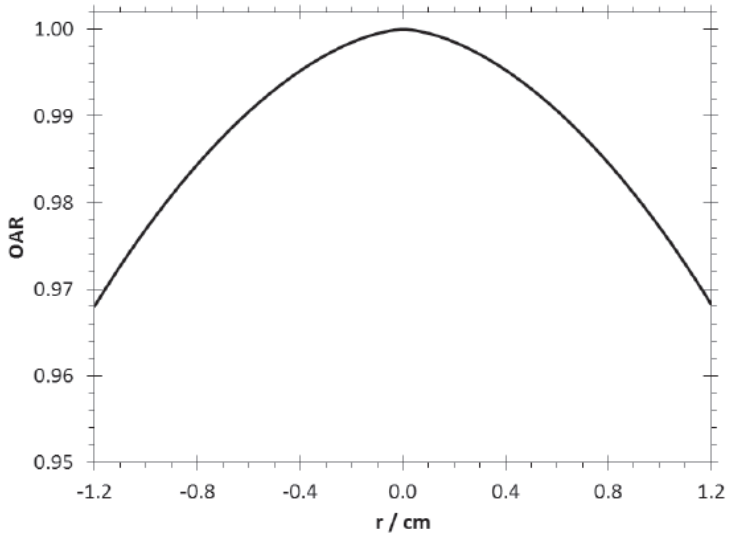
$$k_{Q,Q_o} = \frac{(s_{w,air})_Q}{(s_{w,air})_{Q_o}} \frac{(W_{air})_Q}{(W_{air})_{Q_o}} \frac{p_{ch,Q}}{p_{ch,Q_o}}$$

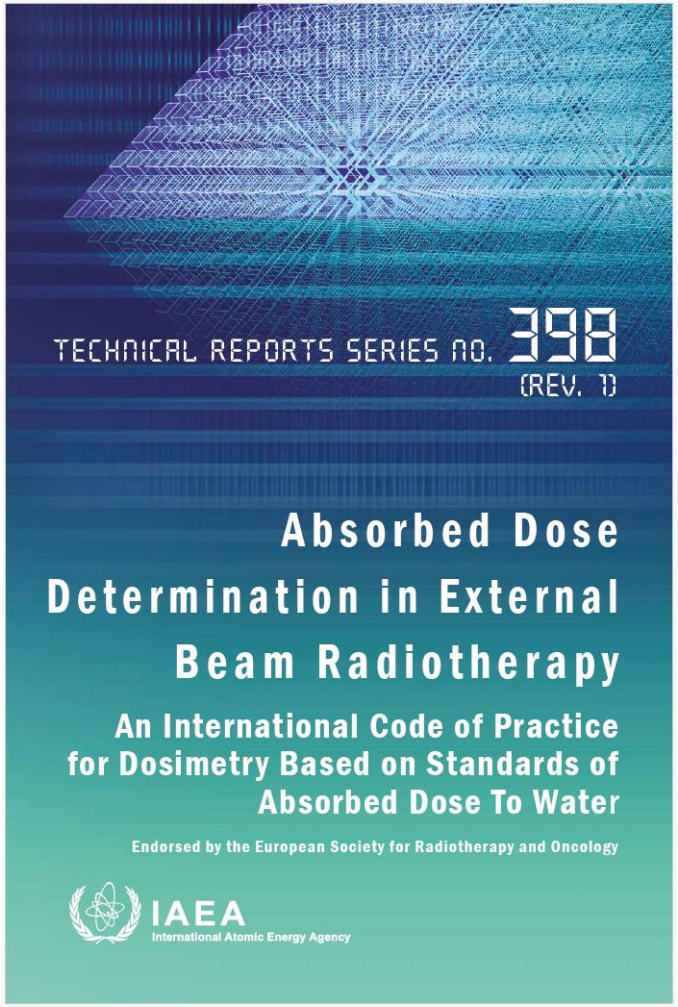
Ohjeeseen päivitetty ja lisätty mm

- k_Q –data päivitetty eri kammiotyypeille
  - uutena kammiotyyppinä Sun Nuclear SNC600c (Farmer)
  - Sun Nuclear SNC350p (tasolevy) – EI DATAA
- Ion.kammioiden tilavuuskorjaus FFF fotonikeiloille k_{vol}

$$(k_{vol})_Q^{f_{ref}} = \frac{\iint_A w(x,y)\,dx\,dy}{\iint_A w(x,y)\,\mathrm{OAR}(x,y)\,dx\,dy}$$







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Ohjeeseen päivitetty ja lisätty mm

- **k_Q –data eri kammiotyypeille esitetty taulukoituna, sekä eksponenttiyhtälön muodossa**

TABLE 16. CALCULATED VALUES[a] OF k_Q FOR HIGH ENERGY PHOTON BEAMS FOR VARIOUS CYLINDRICAL IONIZATION CHAMBERS AS A FUNCTION OF THE BEAM QUALITY INDEX $TPR_{20,10}$ *(see Eq. (34))* (cont.)

Ionization chamber type	Beam quality index, $TPR_{20,10}$											
	0.56	0.59	0.62	0.65	0.68	0.70	0.72	0.74	0.76	0.78	0.80	0.82
PTW 30013 Farmer	1.0007	0.9984	0.9956	0.9920	0.9876	0.9840	0.9800	0.9753	0.9699	0.9636	0.9565	0.9484
IBA FC65-G Farmer	1.0004	0.9990	0.9972	0.9946	0.9912	0.9882	0.9846	0.9802	0.9748	0.9683	0.9603	0.9507
NE 2571 Farmer	1.0004	0.9991	0.9974	0.9951	0.9919	0.9891	0.9856	0.9813	0.9761	0.9697	0.9618	0.9522
Sun Nuclear SNC600c Farmer	1.0004	0.9993	0.9978	0.9957	0.9926	0.9899	0.9866	0.9823	0.9770	0.9703	0.9620	0.9517

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$$k_Q\left(\mathrm{TPR}_{20,10}\right)=\frac{1+\exp\left(\frac{a-0.57}{b}\right)}{1+\exp\left(\frac{a-\mathrm{TPR}_{20,10}}{b}\right)} \qquad (97)$$

Ohjeeseen päivitetty ja lisätty mm

- k_Q **–data eri kammiotyypeille esitetty taulukoituna, sekä eksponenttiyhtälön muodossa**

TABLE 45. CHAMBER TYPES AND NUMBER OF MONTE CARLO DERIVED AND EXPERIMENTAL k_Q DETERMINATIONS FOR HIGH ENERGY PHOTON BEAMS OF DIFFERENT QUALITIES *(adapted from Ref. [100])* (cont.)

Ionization chamber type	Number of data points		Chamber type specific parameters[a]	
	Monte Carlo	Experimental	*a*	*b*
IBA FC65-G Farmer	64	20	1.09752	−0.09642
NE 2571 Farmer	126	28	1.08918	−0.09222
PTW 30013 Farmer	65	23	1.18273	−0.13256
Sun Nuclear SNC600c Farmer[d]	25	5	1.06800	−0.08485

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Ohjeeseen päivitetty ja lisätty mm

- **k_Q –data eri kammiotyypeille esitetty taulukoituna, sekä eksponenttiyhtälön muodossa**

TABLE 20. CALCULATED k_Q VALUES[a] FOR ELECTRON BEAMS, FOR VARIOUS CHAMBER TYPES CALIBRATED IN ^{60}Co GAMMA RADIATION, AS A FUNCTION OF BEAM QUALITY INDEX R_{50}

Ionization chamber type[b]	Beam quality index, R_{50} (g/cm^2)													
	1.0[c]	1.4	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	7.0	8.0	10.0
PTW 34001 Roos	0.9743	0.9645	0.9518	0.9428	0.9349	0.9281	0.9222	0.9171	0.9127	0.9088	0.9055	0.9001	0.8960	0.8907
IBA NACP-02	0.9679	0.9580	0.9451	0.9360	0.9281	0.9214	0.9155	0.9104	0.9061	0.9023	0.8990	0.8938	0.8899	0.8848

$$k_{Q,\mathrm{pp}} = a + be^{-\frac{R_{50,D}}{c}} \qquad (98)$$

TABLE 47. FITTING PARAMETERS FOR k_Q FOR ELECTRON BEAMS FOR VARIOUS CHAMBER TYPES CALIBRATED IN ^{60}Co GAMMA RADIATION

Ionization chamber type[a]	*a*	*b*	*c*
Plane parallel chambers			
PTW 34001 Roos	0.884	0.120	3.511
IBA NACP-02	0.879	0.120	3.398

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Ohjeeseen päivitetty ja lisätty mm

- **Ion.kammioiden tilavuuskorjaus FFF fotonikeiloille k_{vol}**

$$k_{\mathrm{vol}} = 1 + \left(0.0062\,\mathrm{TPR}_{20,10} - 0.0036\right) \times \left(\frac{100}{\mathrm{SDD}}\right)^2 \times L^2 \qquad (22)$$

TABLE 11. GENERIC VALUES FOR THE VOLUME AVERAGING CORRECTION FACTOR IN FLATTERING FILTER FREE BEAMS OF CLINICAL ACCELERATORS

Cavity length, L (cm)	Beam quality index, $\mathrm{TPR}_{20,10}$					
	0.6	0.63	0.66	0.69	0.72	0.75
0.5	1.000	1.000	1.000	1.000	1.000	1.000
1.0	1.000	1.000	1.000	1.001	1.001	1.001
1.5	1.000	1.001	1.001	1.001	1.002	1.002
2.0	1.000	1.001	1.002	1.002	1.003	1.004
2.5	1.001	1.002	1.003	1.004	1.005	1.006

It can be seen from Table 11 that the volume averaging effect is most pronounced for ionization chambers with a long cavity (e.g. Farmer type chambers with $L \approx 2.5$ cm) and in FFF beams of higher energy. Therefore, it is recommended to use ionization chambers with a short cavity for dose measurements in FFF beams for which the correction factor k_{vol} is close to 1.0 and can often be neglected.

Kiitokset mielenkiinnostanne

PeS

17.3.2021