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LAMPIRAN

Lampiran-1: Hasil Penelitan oleh M, Navitha.dkk Tahun 2016

Table 2. 1 Hasil transmisi dengan energi 20 MeV pada tiga penempatan blok dan dua material berbeda

Energi: 20MeV			MU: 100			*Depth*: R_{85} (6.8 cm)	
	All Meter Readings are in nanoColoumb (x 10^{-9}*C)*						
BLOCK POSITION	*Open Field*	*Lead Equivalence sheet*					Cerrobend
		1mm	2mm	3mm	4mm	5mm	5mm
	MR	MR	MR	MR	MR	MR	MR
LOWER LEVEL	1.541	0.609	0.251	0.1452	0.12	0.1106	0.158
	1.537	0.607	0.252	0.1448	0.119	0.1109	0.158
	1.54	0.608	0.252	0.145	0.1195	0.1108	0.158
Average	1.539	0.608	0.0251	0.145	0.1195	0.1108	0.158
Transmission %		39.5	16.35	9.42	7.76	7.2	10.27
CENTER LEVEL	1.541	0.37	0.165	0.1133	0.0974	0.0873	0.1168
	1.537	0.369	0.165	0.1133	0.097	0.0877	0.1163
	1.54	0.369	0.165	0.1133	0.0972	0.0875	0.1165
Average	1.539	0.3693	0.165	0.1133	0.0972	0.0875	0.1165
Transmission %		23.99	10.72	7.36	6.31	5.68	7.57
UPPER LEVEL	1.541	0.312	0.143	0.0991	0.087	0.081	0.1053
	1.537	0.313	0.142	0.0989	0.087	0.0804	0.1045
	1.54	0.311	0.141	0.0989	0.087	0.0808	0.1049
Average	1.539	0.312	0.142	0.099	0.087	0.0807	0.1049
Transmission %		20.77	9.22	6.43	5.65	5.24	6.82

Table 2. 2 Hasil Transmisi dengan energi 16 MeV pada tiga penempatan blok dan dua material berbeda

Energi: 16MeV	MU: 100	*Depth*: R_{85} (5.6 cm)
All Meter Readings are in nanoColoumb (x10^{-9}*C)*		

BLOCK POSITION	*Open Field*	*Lead Equivalence sheet*					Cerrobend
		1mm	2mm	3mm	4mm	5mm	5mm
	MR	MR	MR	MR	MR	MR	MR
LOWER LEVEL	1.521	0.426	0.136	0.081	0.0732	0.0694	0.084
	1.52	0.427	0.136	0.08	0.0731	0.0691	0.0855
	1.519	0.425	0.136	0.08	0.073	0.0693	0.0848
Average	1.52	0.426	0.136	0.0803	0.0731	0.0693	0.0848
Transmission %		28.03	8.95	5.29	4.81	4.56	5.58
CENTER LEVEL	1.521	0.228	0.0875	0.0616	0.0559	0.0528	0.0627
	1.52	0.229	0.087	0.061	0.0559	0.0529	0.0626
	1.519	0.227	0.0872	0.0613	0.0559	0.053	0.06265
Average	1.52	0.228	0.08723	0.0613	0.0559	0.0529	0.06265
Transmission %		15	5.74	4.03	3.68	3.48	4.12
UPPER LEVEL	1.521	0.186	0.0737	0.0557	0.0507	0.0477	0.0569
	1.52	0.185	0.0737	0.0556	0.051	0.0475	0.057
	1.519	0.187	0.0737	0.0555	0.0508	0.0476	0.05695
Average	1.52	0.186	0.0737	0.0556	0.0508	0.0476	0.05695
Transmission %		12.24	4.85	3.66	3.34	3.13	3.75

Table 2. 3 Hasil Transmisi dengan energi 12 MeV pada tiga penempatan blok dan dua material berbeda

Energi: 12MeV			MU: 100		*Depth*: R_{85} (4.3 cm)		
All Meter Readings are in nanoColoumb ($x10^{-9}C$)							
BLOCK POSITION	*Open Field*	*Lead Equivalence sheet*					Cerrobend
		1mm	2mm	3mm	4mm	5mm	5mm
	MR	MR	MR	MR	MR	MR	MR
LOWER LEVEL	1.508	0.243	0.0552	0.0433	0.0408	0.0389	0.045
	1.507	0.241	0.0552	0.0435	0.0414	0.0386	0.0447
	1.507	0.242	0.0552	0.0434	0.0404	0.0388	0.0448
Average	1.507	0.2419	0.0552	0.0434	0.0409	0.0388	0.0448
Transmission %		16.05	3.66	2.88	2.71	2.57	2.98

CENTER	1.508	0.1168	0.0382	0.031	0.0294	0.0275	0.031
LEVEL	1.507	0.1167	0.0382	0.031	0.0296	0.0271	0.032
	1.507	0.117	0.0382	0.031	0.0292	0.0273	0.0315
Average	1.507	0.1168	0.0382	0.031	0.0294	0.0273	0.0315
Transmission %		7.75	2.54	2.06	1.95	1.81	2.09
UPPER	1.508	0.0929	0.0318	0.0269	0.0256	0.024	0.028
LEVEL	1.507	0.0927	0.0321	0.0271	0.0258	0.0244	0.027
	1.507	0.0926	0.032	0.0267	0.0257	0.0242	0.0275
Average	1.507	0.0927	0.032	0.0269	0.0257	0.0242	0.0275
Transmission %		6.15	2.12	1.78	1.7	1.61	1.82

Table 2. 4 Hasil Transmisi dengan energi 9 MeV pada tiga penempatan blok dan dua material berbeda

Energi: 9MeV			MU: 100		*Depth*: R_{85} (3.0cm)		
	All Meter Readings are in nanoColoumb ($x10^{-9}C$)						
BLOCK POSITION	*Open*	*Lead Equivalence sheet*					Cerrobend
	Field	1mm	2mm	3mm	4mm	5mm	5mm
	MR	MR	MR	MR	MR	MR	MR
	1.507	0.13	0.024	0.024	0.021	0.0197	0.0225
LOWER LEVEL	1.502	0.131	0.025	0.022	0.0211	0.0194	0.0227
	1.504	0.131	0.024	0.023	0.0209	0.0196	0.0226
Average	1.504	0.1307	0.0243	0.023	0.021	0.0196	0.0226
Transmission %		8.69	1.62	1.53	1.4	1.3	1.5
CENTER	1.507	0.0567	0.0192	0.0186	0.0178	0.0161	0.015
LEVEL	1.502	0.0564	0.0192	0.0191	0.0177	0.0159	0.0148
	1.504	0.0566	0.0192	0.0189	0.0176	0.016	0.0149
Average	1.504	0.0566	0.0192	0.0189	0.0177	0.016	0.0149
Transmission %		3.76	1.28	1.25	1.18	1.06	0.99
UPPER	1.507	0.0454	0.0144	0.0135	0.0122	0.0118	0.0135
LEVEL	1.502	0.0455	0.0139	0.0135	0.0121	0.0121	0.0138
	1.504	0.0454	0.0142	0.0136	0.012	0.0119	0.0136
Average	1.504	0.0454	0.0142	0.0135	0.0121	0.0119	0.0136

Transmission %	3.02	0.94	0.9	0.8	0.79	0.91

Table 2. 5 Hasil Transmisi dengan energi 6 MeV pada tiga penempatan blok dan dua material berbeda

Energy: 6MeV			MU: 100		Depth: R_{85} (2.0 cm)		
All Meter Readings are in nanoColoumb ($x10^{-9}C$)							
BLOCK POSITION	Open Field	Lead Equivalence sheet					Cerrobend
		1mm	2mm	3mm	4mm	5mm	5mm
	MR	MR	MR	MR	MR	MR	MR
LOWER LEVEL	1.433	0.0356	0.0128	0.011	0.0107	0.0099	0.0114
	1.433	0.0354	0.0127	0.0112	0.0111	0.0109	0.0114
	1.435	0.0358	0.0127	0.012	0.0104	0.0106	0.0114
Average	1.434	0.0356	0.0127	0.0114	0.0107	0.0105	0.0114
Transmission %		2.48	0.89	0.8	0.75	0.73	0.79
CENTER LEVEL	1.433	0.017	0.0087	0.0075	0.0073	0.0064	0.0077
	1.433	0.0173	0.0087	0.0079	0.007	0.0064	0.0072
	1.435	0.0169	0.0084	0.0071	0.0071	0.0064	0.00745
Average	1.434	0.0171	0.0086	0.0075	0.0071	0.0064	0.00745
Transmission %		1.19	0.6	0.52	0.5	0.45	0.52
UPPER LEVEL	1.433	0.0136	0.0083	0.0078	0.0075	0.0067	0.007
	1.433	0.0137	0.0082	0.0074	0.0072	0.0068	0.007
	1.435	0.0138	0.0081	0.0069	0.0073	0.0066	0.007
Average	1.434	0.0137	0.0082	0.0074	0.0073	0.0067	0.007
Transmission %		0.96	0.57	0.51	0.51	0.47	0.49

Lampiran-2: Lembar data Pengukuran

LEMBAR DATA

Pesawat	Linac Elekta
Detektor	PTW Markus
Suhu	21
Tekanan	1004
Kelembaban	56
Dose Rate	400
Tegangan	+300 V
Phantom	30×30× 10 cm^2

Energi = 8 MeV			MU = 200				Depth = Permukaan			
All Meter Reading are in Gray (Gy)										
Block Posision	Open Filed	Cerrobend Sheet			Teflon Sheet			Pb Sheet		
		Ketebalan (cm)								
		0,5 cm	1 cm	1,5 cm	0,5 cm	1 cm	1,5 cm	0,2 cm	0,5 cm	1 cm
Pengukuran	3,688	0,1122	0,07034	0,0665	3,593	2,656	1,571	0,08301	0,07912	0,05844
	3,697	0,1126	0,07086	0,06684	3,604	2,657	1,575	0,08439	0,07924	0,05888
	3,697	0,1126	0,07098	0,06646	3,432	2,661	1,521	0,08483	0,07976	0,05912
Rata- rata	3,694	0,112467	0,0707267	0,0666	3,543	2,658	1,5556	0,08407667	0,0793733	0,05881

Energi = 10 MeV			MU = 200				Depth = Permukaan			
All Meter Reading are in Gray (Gy)										
Block Posision	Open Filed	Cerrobend Sheet			Teflon Sheet			Pb Sheet		
		Ketebalan (cm)								
		0,5 cm	1 cm	1,5 cm	0,5 cm	1 cm	1,5 cm	0,2 cm	0,5 cm	1 cm
Pengukuran	3,773	0,1446	0,08728	0,07878	3,813	3,187	2,31	0,121	0,1028	0,07322
	3,774	0,1416	0,08706	0,07862	3,818	3,193	2,316	0,12123	0,1027	0,07314
	3,769	0,1411	0,08716	0,07872	3,817	3,187	2,315	0,12165	0,1025	0,0731
Rata- rata	3,772	0,142433	0,08716	0,0787067	3,816	3,189	2,3136	0,12129333	0,1026	0,07315

Energi = 8 MeV		MU = 200				Depth = Z_{max} (1,7cm)			
All Meter Reading are in Gray (Gy)									
Block Posision	Open Filed	Cerrobend Sheet			Teflon Sheet			Pb Sheet	
		Ketebalan (cm)							
		0,5 cm	1 cm	1,5 cm	0,5 cm	1 cm	1,5 cm	0,2 cm	0,5 cm	1 cm
Pengukuran	4,135	0,0708	0,0556	0,04692	3,114	0,8821	0,1025	0,07495	0,06228	0,04438
	4,145	0,07084	0,05596	0,04736	3,126	0,897	0,1026	0,07506	0,0621	0,04448
	4,144	0,0711	0,05612	0,0474	3,125	0,8928	0,1034	0,07445	0,06268	0,04492
Rata- rata	4,1413	0,070913	0,055893	0,047226	3,1216	0,890633	0,10283	0,07482	0,062354	0,04459

Energi = 10 MeV			MU = 200				Depth = Z_{max} (2,1 cm)			
All Meter Reading are in Gray (Gy)										
Block Posision	Open Filed	Cerrobend Sheet			Teflon Sheet			Pb Sheet		
		Ketebalan (cm)								
		0,5 cm	1 cm	1,5cm	0,5 cm	1 cm	1,5 cm	0,2 cm	0,5 cm	1 cm
Pengukuran	4,125	0,08666	0,06242	0,05414	3,557	1,700	0,3426	0,08498	0,07496	0,05618
	4,121	0,08744	0,06216	0,05406	3,557	1,713	0,3421	0,08521	0,07538	0,05662
	4,121	0,08754	0,06288	0,05414	3,554	1,715	0,3454	0,08534	0,07554	0,05668
Rata- rata	4,1223	0,0872133	0,062486	0,054113	3,556	1,7093	0,343367	0,085176	0,07529	0,05649

Lampiran-3 : Hasil perhitungan rata-rata setiap pengukuran

Energi = 8 MeV		Depth = Permukaan	
Lapangan Terbuka	Cerrobend Sheet (Ketebalan 0.5 cm)	Cerrobend Sheet (Ketebalan 1 cm)	Cerrobend Sheet (Ketebalan 1.5 cm)
Rata -Rata = $\frac{3.688+3.697+3.697}{3}$ = 3.694 Gy	Rata -Rata = $\frac{0.1122+0.1126+0.1126}{3}$ = 0.112467 Gy	Rata -Rata = $\frac{0.07034+0.07086+0.07098}{3}$ = 0.0707267 Gy	Rata -Rata = $\frac{0.0665+0.06684+0.06646}{3}$ = 0.0666 Gy
	Teflon Sheet (Ketebalan 0.5 cm)	Teflon Sheet (Ketebalan 1 cm)	Teflon Sheet (Ketebalan 1.5 cm)
	$\frac{3.593+3.604+3.432}{3}$ = 3.543 Gy	$\frac{2,656+2,657+2,661}{3}$ = 2.658 Gy	$\frac{1,571+1,575+1,521}{3}$ =1.5556 Gy

	Pb Sheet (Ketebalan 0.2 cm)	Pb Sheet (Ketebalan 0.5 cm)	Pb Sheet (Ketebalan 1cm)
	$\frac{0,08301+0,08439+0,08483}{3}$ = 0.08407667 Gy	$\frac{0,07912+0,07924+0,07976}{3}$ = 0.0793733 Gy	$\frac{0,05844+0,05888+0,0591}{3}$ = 0.05881 Gy

Energi = 10 MeV		Depth = Permukaan	
Lapangan Terbuka	Cerrobend Sheet (Ketebalan 0.5 cm)	Cerrobend Sheet (Ketebalan 1 cm)	Cerrobend Sheet (Ketebalan 1.5 cm)
Rata -Rata = $\frac{3,773+3,774+3,76}{3}$ = 3.772 Gy	Rata -Rata = $\frac{0,1446+0,1416+0,1411}{3}$ = 0.142433 Gy	Rata -Rata = $\frac{0,08728+0,08706+0,08716}{3}$ = 0.08716 Gy	Rata -Rata = $\frac{0,07878+0,07862+0,07872}{3}$ = 0.0787067 Gy
	Teflon Sheet (Ketebalan 0.5 cm)	Teflon Sheet (Ketebalan 1 cm)	Teflon Sheet (Ketebalan 1.5 cm)
	$\frac{3,813+3,818+3,817}{3}$ = 3.816 Gy	$\frac{3,1873+3.1933+3,187}{3}$ = 3.189 Gy	$\frac{2,310+2,316+2,315}{3}$ = 2.3136 Gy
	Pb Sheet (Ketebalan 0.2 cm)	Pb Sheet (Ketebalan 0.5 cm)	Pb Sheet (Ketebalan 1cm)
	$\frac{0,1210+0,12123+0,12165}{3}$ = 0.12129333 Gy	$\frac{0,1028+0,1027+0,1025}{3}$ = 0.1026 Gy	$\frac{0,07322+0,07314+0,0731}{3}$ = 0.07315 Gy

Energi = 8 MeV		Depth = Z_{max} (1,7cm)	
Lapangan Terbuka	Cerrobend Sheet (Ketebalan 0.5 cm)	Cerrobend Sheet (Ketebalan 1 cm)	Cerrobend Sheet (Ketebalan 1.5 cm)
Rata -Rata = $\frac{4,135+4,145+4,144}{3}$ = 4.1413 Gy	Rata -Rata = $\frac{0,0708+0,07084+0,0711}{3}$ = 0.070913 Gy	Rata -Rata = $\frac{0,0556+0,05596+0,05612}{3}$ = 0.055893 Gy	Rata -Rata = $\frac{0,04692+0,04736+0,0474}{3}$ = 0.047226 Gy
	Teflon Sheet (Ketebalan 0.5 cm)	Teflon Sheet (Ketebalan 1 cm)	Teflon Sheet (Ketebalan 1.5 cm)

	$\frac{3,114+3,126+3,125}{3}$ = 3.1216 Gy	$\frac{0,8821+0,897+0,8928}{3}$ = 0.890633 Gy	$\frac{0,1025+0,1026+0,1034}{3}$ = 0.10283 Gy
	Pb Sheet (Ketebalan 0.2 cm)	Pb Sheet (Ketebalan 0.5 cm)	Pb Sheet (Ketebalan 1cm)
	$\frac{0,07495+0,07506+0,07445}{3}$ = 0.07482 Gy	$\frac{0,06228+0,0621+0,06268}{3}$ = 0.062354 Gy	$\frac{0,04438+0,04448+0,0449}{3}$ = 0.04459 Gy

Energi = 10 MeV		Depth = Z_{max} (2,1 cm)	
Lapangan Terbuka	Cerrobend Sheet (Ketebalan 0.5 cm)	Cerrobend Sheet (Ketebalan 1 cm)	Cerrobend Sheet (Ketebalan 1.5 cm)
Rata -Rata = $\frac{4,125+4,121+4,12}{3}$ = 4.1223 Gy	Rata -Rata = $\frac{0,08666+0,08744+0,08754}{3}$ = 0.0872133 Gy	Rata -Rata = $\frac{0,06242+0,06216+0,06288}{3}$ =0.062486 Gy	Rata -Rata = $\frac{0,05414+0,05406+0,05414}{3}$ = 0.054113 Gy
	Teflon Sheet (Ketebalan 0.5 cm)	Teflon Sheet (Ketebalan 1 cm)	Teflon Sheet (Ketebalan 1.5 cm)
	$\frac{3,557+3,557+3,554}{3}$ = 3.556 Gy	$\frac{1,700+1,713+1,715}{3}$ = 1.7093 Gy	$\frac{0,3426+0,3421+0,3454}{3}$ = 0.343367 Gy
	Pb Sheet (Ketebalan 0.2 cm)	Pb Sheet (Ketebalan 0.5 cm)	Pb Sheet (Ketebalan 1cm)
	$\frac{0,08498+0,08521+0,08534}{3}$ = 0.085176 Gy	$\frac{0,07496+0,07538+0,07554}{3}$ = 0.07529 Gy	$\frac{0,05618+0,05662+0,05668}{3}$ = 0.05649 Gy

Lampiran-4 : Hasil perhitungan Presentase Transmisi

Perhitungan % pada masing- masing material pengukuran pada permukaan *phantom* dan Z_{max} *phantom* dengan energi 8 MeV dan 10 MeV

- Material Cerrobend energi 8 Mev pengukuran pada permukaan *phantom*

Ketebalan 0,5 cm	Ketebalan 1 cm	Ketebalan 1,5 cm
Dosis tanpa blok individual : 3.694 Gy	Dosis tanpa blok individual : 3.694 Gy	Dosis tanpa blok individual : 3.694 Gy
$\% = \frac{0.112467\ \text{Gy}}{3.694\ \text{Gy}} \times 100\%$ = 3.04%	$\% = \frac{0.0707267\ \text{Gy}}{3.694\ \text{Gy}} \times 100\%$ = 1.91%	$\% = \frac{0.0666\ \text{Gy}}{3.694\ \text{Gy}} \times 100\%$ = 1.802%

- Material Teflon energi 8 Mev pengukuran pada permukaan *phantom*

Ketebalan 0,5 cm	Ketebalan 1 cm	Ketebalan 1,5 cm
Dosis tanpa blok individual : 3.694 Gy	Dosis tanpa blok individual : 3.694 Gy	Dosis tanpa blok individual : 3,694 Gy
$\% = \frac{3.543\ \text{Gy}}{3.694\ \text{Gy}} \times 100\%$ = 95.91%	$\% = \frac{2.658\ \text{Gy}}{3.694\ \text{Gy}} \times 100\%$ = 71.95%	$\% = \frac{1.5556\ \text{Gy}}{3.694\ \text{Gy}} \times 100\%$ = 42.11%

- Material Pb energi 8 Mev pengukuran pada permukaan *phantom*

Ketebalan 0.2 cm	Ketebalan 0.5 cm	Ketebalan 1 cm
Dosis tanpa blok individual : 3.694 Gy	Dosis tanpa blok individual : 3.694 Gy	Dosis tanpa blok individual : 3,694 Gy
$\% = \frac{0,08407667\ \text{Gy}}{3,694\ \text{Gy}} \times 100\%$ = 2.27%	$\% = \frac{0.0793733\ \text{Gy}}{3.694\ \text{Gy}} \times 100\%$ = 2.14 %	$\% = \frac{1.59213\text{Gy}}{3.694\ \text{Gy}} \times 100\%$ = 1.59 %

- Material Cerrobend energi 10 Mev pengukuran pada permukaan *phantom*

Ketebalan 0.5 cm	Ketebalan 1 cm	Ketebalan 1.5 cm
Dosis tanpa blok individual : 3.772 Gy	Dosis tanpa blok individual : 3.772 Gy	Dosis tanpa blok individual : 3.772 Gy

$\% = \frac{0.142433\ \text{Gy}}{3.772\ \text{Gy}} \times 100\%$ = 3.77 %	$\% = \frac{0.08716\ \text{Gy}}{3.772\ \text{Gy}} \times 100\%$ = 2.31 %	$\% = \frac{0.0787067\ \text{Gy}}{3.772\ \text{Gy}} \times 100\%$ = 2.08 %

- Material Teflon energi 10 Mev pengukuran pada permukaan *phantom*

Ketebalan 0.5 cm	Ketebalan 1 cm	Ketebalan 1.5 cm
Dosis tanpa blok individual : 3.772 Gy	Dosis tanpa blok individual : 3.772 Gy	Dosis tanpa blok individual : 3.772 Gy
$\% = \frac{101.16649\text{Gy}}{3.772\ \text{Gy}} \times 100\%$ = 101.16 %	$\% = \frac{84.544008\ \text{Gy}}{3.772\ \text{Gy}} \times 100\%$ = 84.54 %	$\% = \frac{61.3361612\ \text{Gy}}{3.772\ \text{Gy}} \times 100\%$ = 61.33 %

- Material Pb energi 10 Mev pengukuran pada permukaan *phantom*

Ketebalan 0.2 cm	Ketebalan 0.5 cm	Ketebalan 1 cm
Dosis tanpa blok individual : 3.772 Gy	Dosis tanpa blok individual : 3.772 Gy	Dosis tanpa blok individual : 3.772 Gy
$\% = \frac{0.1212934}{3.772\ \text{Gy}} \times 100\%$ = 3.12%	$\% = \frac{0.1026\ \text{Gy}}{3.772\ \text{Gy}} \times 100\%$ = 2.72 %	$\% = \frac{0{,}0731533\ \text{Gy}}{3.772\ \text{Gy}} \times 100\%$ = 1.73 %

- Material Cerrobend energi 8 Mev pengukuran pada Z_{max} *phantom*

Ketebalan 0.5 cm	Ketebalan 1 cm	Ketebalan 1.5 cm
Dosis tanpa blok individual : 4.1413 Gy	Dosis tanpa blok individual : 4.1413 Gy	Dosis tanpa blok individual : 4.1413 Gy
$\% = \frac{0.0709133\ \text{Gy}}{4.1413\ \text{Gy}} \times 100\%$ = 1.71 %	$\% = \frac{0.055893\text{Gy}}{4.1413\ \text{Gy}} \times 100\%$ = 1.34 %	$\% = \frac{0.0472267\ \text{Gy}}{4.1413\ \text{Gy}} \times 100\%$ = 1.14 %

- Material Teflon energi 8 Mev pengukuran pada Z_{max} *phantom*

Ketebalan 0.5 cm	Ketebalan 1 cm	Ketebalan 1.5 cm
Dosis tanpa blok individual : 4.1413 Gy	Dosis tanpa blok individual : 4.1413 Gy	Dosis tanpa blok individual : 4.1413 Gy

$\% = \frac{3.1216\ Gy}{4.1413\ Gy} \times 100\%$ $= 75.37\ \%$	$\% = \frac{0.890633\ Gy}{4.1413\ Gy} \times 100\%$ $= 21.506\ \%$	$\% = \frac{0.10283\ Gy}{4.1413\ Gy} \times 100\%$ $= 2.483\ \%$

- Material Pb energi 8 Mev pengukuran pada Z_{max} *phantom*

Ketebalan 0.2 cm	Ketebalan 0.5 cm	Ketebalan 1 cm
Dosis tanpa blok individual : 4.1413 Gy	Dosis tanpa blok individual : 4.1413 Gy	Dosis tanpa blok individual : 4.1413 Gy
$\% = \frac{0.07482\ Gy}{4.1413\ Gy} \times 100\%$ $= 1.806\ \%$	$\% = \frac{1.50564638\ Gy}{4.1413\ Gy} \times 100\%$ $= 1.505\ \%$	$\% = \frac{0.0445933\ Gy}{4.1413\ Gy} \times 100\%$ $= 1.07\ \%$

- Material Cerrobend energi 10 Mev pengukuran pada Z_{max} *phantom*

Ketebalan 0.5 cm	Ketebalan 1 cm	Ketebalan 1.5 cm
Dosis tanpa blok individual : 4.1223 Gy	Dosis tanpa blok individual : 4.1223 Gy	Dosis tanpa blok individual : 4.1223 Gy
$\% = \frac{0.0872133\ Gy}{4{,}1223\ Gy} \times 100\%$ $= 2.11\ \%$	$\% = \frac{0.0624867\ Gy}{4.1223\ Gy} \times 100\%$ $= 1.51\ \%$	$\% = \frac{0.0541133\ Gy}{4.1223\ Gy} \times 100\%$ $= 1.31\ \%$

- Material Teflon energi 10 Mev pengukuran pada Z_{max} *phantom*

Ketebalan 0.5 cm	Ketebalan 1 cm	Ketebalan 1.5 cm
Dosis tanpa blok individual : 4.1223 Gy	Dosis tanpa blok individual : 4.1223 Gy	Dosis tanpa blok individual : 4.1223 Gy
$\% = \frac{3.556\ Gy}{4.1223\ Gy} \times 100\%$ $= 86.26\ \%$	$\% = \frac{1.7093\ Gy}{4.1223\ Gy} \times 100\%$ $= 41.46\ \%$	$\% = \frac{0.343367\ Gy}{4.1223\ Gy} \times 100\%$ $= 8.32\ \%$

- Material Pb energi 10 Mev pengukuran pada Z_{max} *phantom*

Ketebalan 0.2 cm	Ketebalan 0.5 cm	Ketebalan 1 cm

Dosis tanpa blok individual : 4.1223 Gy	Dosis tanpa blok individual : 4.1223 Gy	Dosis tanpa blok individual : 4.1223 Gy
$\% = \frac{0.085176667 Gy}{4.1223\ Gy} \times 100\%$ = 2.06 %	$\% = \frac{0.0752933\ Gy}{4.1223\ Gy} \times 100\%$ = 1.82 %	$\% = \frac{0.05649\ Gy}{4.1223\ Gy} \times 100\%$ = 1.37 %

Lampiran-5 : Data sekunder Pengukuran pada z_{max} mengunakan water phantom dengan energi 8 dan 10 MeV

Worksheet for the determination of the absorbed dose to water in an electron-beam

User: **RSPAD GS** Date: **24-Jun-22**

1. Radiation treatment unit and reference conditions for $D_{w,Q}$ determination

Accelerator: **elekta Precise**
s/n 1503

Nominal energy: **10,000** MeV

Nominal dose rate: **400,0** MU min^{-1} Measured R_{50} : **4,050** g cm^{-2}

Reference phantom: ☑ water ☐ plastic obtained from ☐ ionization ☑ dose curves

Reference field size: **10x10** cm x cm Reference SSD: **100** cm

Beam quality, Q ($R_{50,w}$) **4,050** g cm^{-2} Ref. depth $z_{ref,w}$ = 0.6 R_{50} - 0.1: **2,3** g cm^{-2}

2. Ionization chamber and electrometer

Ion. chamber model: Markus Serial No.: ☑ pp ☐ cyl

Chamber wall / window material: **Polyethylene** thickness: **0,1020** g cm^{-2}

Waterproof sleeve material: thickness: g cm^{-2}

Phantom window material: thickness: g cm^{-2}

Abs. dose-to-water calibration factor [a] N_{D,w,Q_0} = **0,5612** ☑ Gy/nC ☐ Gy/rdg

Calibration quality Q_0: ☑ Co-60 ☐ electron beam Calibration depth: **5,0** g cm^{-2}

If Q_0 is electron beam, give $R_{50,w}$: g cm^{-2}

Reference conditions for calibration

P_0: **101,3** kPa T_0: **20,0** °C Rel. humidity: **50** %

Pol. potential V_1: **400** V Calib. polarity: ☑ +ve ☐ -ve ☑ corrected for polarity effect
User polarity: ☑ +ve ☐ -ve

Calibration laboratory: **BATAN** Date: **13 Oktober 2009**

Electrometer model: **PTW Tandem** Serial no.:

Calib. separately from chamber: ☐ yes ☑ no Range setting:

If yes Calibration laboratory: Date:

3. Phantom

Water phantom window material: thickness: g cm^{-2}

Plastic phantom phantom material: density: g cm^{-3}

depth scaling factor c_{pl}: reference depth $z_{ref,pl} = z_{ref} / c_{pl}$: g cm^{-2}

fluence scaling factor : h_{pl} =

4. Dosimetry reading [b] **and correction for influence quantities**

Uncorrected dosimeter reading at V_1 and user polarity: **1,93** ☑ nC ☐ rdg

Corresponding accelerator monitor units: **100** MU

Ratio of dosimeter reading and monitor units: M_1 = **0,0193** ☑ nC/MU ☐ rdg/MU

(i) P: **101,0** kPa T: **22,0** °C Rel. humidity: **62** %

$$k_{TP} = \frac{(273.2 + T)\, P_0}{(273.2 + T_0)\, P} = \mathbf{1{,}0101}$$

(ii) Electrometer calibration factor k_{elec} = ☐ nC/rdg ☐ dimensionless

(iii) Polarity correction [c] rdg at $+V_1$: M_+ = **1,919** rdg at $-V_1$: M_- = **1,938**

$$k_{pol} = \frac{|M_+| + |M_-|}{2M} = \mathbf{1{,}0050}$$

(iv) Recombination correction (two-voltage method)

Polarizing voltages: V_1 (normal) = **300** V V_2 (reduced) = **100** V

Readings at each V: M_1 = **1,919** M_2 = **1,91**

Voltage ratio V_1 / V_2 = **3,0000** Read. ratio M_1 / M_2 = **1,0047**

Beam type: ☑ pulsed ☐ pulsed-scanned

a_0 = 1,1980 a_1 = -0,8753 a_2 = 0,6773

$$k_s = a_0 + a_1\left(\frac{M_1}{M_2}\right) + a_2\left(\frac{M_1}{M_2}\right)^2 = \mathbf{1{,}0023}$$ [d]

Corrected dosimeter reading at the voltage V_1:

$$M_Q = M_1\, h_{pl}\, k_{TP}\, k_{elec}\, k_{pol}\, k_s = $$ **1,9635E-02** ☑ nC / MU ☐ rdg / MU

5. Absorbed dose to water at the reference depth, z_{ref}

Beam quality correction factor for user quality Q:

If Q_0 is ^{60}Co Table 18 gives $k_{Q,Q_0} =$ **0,910**

If Q_0 is electron beam Table 19 gives $k_{Q,Q_{int}} =$ $k_{Q_0,Q_{int}} =$

Use k_{Q,Q_0} derived from

$$k_{Q,Q_0} = \frac{k_{Q,Q_{int}}}{k_{Q_o,Q_{int}}} =$$

If k_{Q,Q_0} is derived from series of electron beam calibrations $k_{Q,Q_0} =$

Calibration laboratory: Date:

$$D_{w,Q}(z_{ref}) = M_Q\, N_{D,w,Q_0}\, k_{Q,Q_0} = $$ **1,0024E-02** Gy / MU

6. Absorbed dose rate to water at the depth of dose maximum, z_{max}

Depth of dose maximum: z_{max} = **2,10** g cm^{-2}

Percentage depth-dose at z_{ref} for a 10x10 cm x cm field size:

$PDD(z_{ref}$ 2,3 g cm^{-2}) = **99,90** %

Absorbed-dose calibration of monitor at z_{max} :

$$D_{w,Q}(z_{\max}) = 100\, D_{w,Q}(z_{ref}) / PDD(z_{ref}) = $$ **1,0034E-02** Gy / MU

Notes:

[a] Note that if Q_0 is ^{60}Co, N_{D,w,Q_0} is denoted $N_{D,w}$

[b] All readings should be checked for leakage and corrected if necessary

[c] M in the denominator of k_{pol} denotes reading at the user polarity. Preferably, each reading in the equation should be the average of the ratios of M (or M_+ or M_-) to the reading of an external monitor, M_{em}.

[d] Check that $k_s - 1 \approx \frac{M_1/M_2 - 1}{V_1/V_2 - 1}$

$k_s - 1 =$ **0,002**

$\frac{M_1/M_2 - 1}{V_1/V_2 - 1} =$ **0,002**

Worksheet for the determination of the absorbed dose to water in an electron-beam

User: **RSPAD GS** Date: **24-Jun-22**

1. Radiation treatment unit and reference conditions for $D_{w,Q}$ determination

Accelerator: **elekta Precise**
s/n 1503 Nominal energy: **8,000** MeV
Nominal dose rate: **400,0** MU min^{-1} Measured R_{50} : **3,234** g cm^{-2}
Reference phantom: ☑ water ☐ plastic obtained from ☐ ionization ☑ dose curves
Reference field size: **10x10** cm x cm Reference SSD: **100** cm
Beam quality, Q ($R_{50,w}$) **3,234** g cm^{-2} Ref. depth $z_{ref,w}$ = 0.6 R_{50} - 0.1: **1,8** g cm^{-2}

2. Ionization chamber and electrometer

Ion. chamber model: Markus Serial No.: ☑ pp ☐ cyl
Chamber wall / window material: **Polyethylene** thickness: **0,1020** g cm^{-2}
Waterproof sleeve material: thickness: g cm^{-2}
Phantom window material: thickness: g cm^{-2}

Abs. dose-to-water calibration factor [a] N_{D,w,Q_0} = **0,5612** ☑ Gy/nC ☐ Gy/rdg
Calibration quality Q_0: ☑ Co-60 ☐ electron beam Calibration depth: **5,0** g cm^{-2}
If Q_0 is electron beam, give $R_{50,w}$: g cm^{-2}
Reference conditions for calibration
P_0: **101,3** kPa T_0: **20,0** °C Rel. humidity: **50** %

Pol. potential V_1: **400** V Calib. polarity: ☑ +ve ☐ -ve ☑ corrected for polarity effect
User polarity: ☑ +ve ☐ -ve

Calibration laboratory: **BATAN** Date: **13 Oktober 2009**
Electrometer model: **PTW Tandem** Serial no.:
Calib. separately from chamber: ☐ yes ☑ no Range setting:
If yes Calibration laboratory: Date:

3. Phantom

Water phantom window material: thickness: g cm^{-2}
Plastic phantom phantom material: density: g cm^{-3}
depth scaling factor c_{pl}: reference depth $z_{ref,pl} = z_{ref} / c_{pl}$: g cm^{-2}
fluence scaling factor : h_{pl} =

4. Dosimetry reading [b] and correction for influence quantities

Uncorrected dosimeter reading at V_1 and user polarity: **1,91** ☑ nC ☐ rdg
Corresponding accelerator monitor units: **100** MU
Ratio of dosimeter reading and monitor units: M_1 = **0,0191** ☑ nC/MU ☐ rdg/MU

(i) P: **101,0** kPa T: **22,0** °C Rel. humidity: **62** %

$$k_{TP} = \frac{(273.2 + T)\,P_0}{(273.2 + T_0)\,P} = 1{,}0101$$

(ii) Electrometer calibration factor k_{elec} = ☐ nC/rdg ☐ dimensionless

(iii) Polarity correction [c] rdg at $+V_1$: M_+ = **1,91** rdg at $-V_1$: M_- = **1,927**

$$k_{pol} = \frac{|M_+| + |M_-|}{2M} = 1{,}0045$$

(iv) Recombination correction (two-voltage method)
Polarizing voltages: V_1 (normal) = **300** V V_2 (reduced) = **100** V
Readings at each V: M_1 = **1,91** M_2 = **1,899**
Voltage ratio V_1 / V_2 = **3,0000** Read. ratio M_1 / M_2 = **1,0058**
Beam type: ☑ pulsed ☐ pulsed-scanned
a_0 = 1,1980 a_1 = -0,8753 a_2 = 0,6773

$$k_s = a_0 + a_1\left(\frac{M_1}{M_2}\right) + a_2\left(\frac{M_1}{M_2}\right)^2 = 1{,}0028$$ [d]

Corrected dosimeter reading at the voltage V_1:

$$M_Q = M_1\, h_{pl}\, k_{TP}\, k_{elec}\, k_{pol}\, k_s = \textbf{1,9432E-02}$$ ☑ nC / MU ☐ rdg / MU

5. Absorbed dose to water at the reference depth, z_{ref}

Beam quality correction factor for user quality Q:

If Q_0 is ^{60}Co Table 18 gives $k_{Q,Q_0} =$ **0,915**

If Q_0 is electron beam Table 19 gives $k_{Q,Q_{int}} =$ $k_{Q_0,Q_{int}} =$

Use k_{Q,Q_0} derived from $k_{Q,Q_0} = \dfrac{k_{Q,Q_{int}}}{k_{Q_0,Q_{int}}} =$

If k_{Q,Q_0} is derived from series of electron beam calibrations $k_{Q,Q_0} =$

Calibration laboratory: Date:

$$D_{w,Q}(z_{ref}) = M_Q\, N_{D,w,Q_0}\, k_{Q,Q_0} = \textbf{9,9740E-03} \text{ Gy / MU}$$

6. Absorbed dose rate to water at the depth of dose maximum, z_{max}

Depth of dose maximum: z_{max} = **1,70** g cm^{-2}

Percentage depth-dose at z_{ref} for a 10x10 cm x cm field size:

$PDD(z_{ref}$ 1,8 g cm^{-2}) = **99,90** %

Absorbed-dose calibration of monitor at z_{max} :

$$D_{w,Q}(z_{\max}) = 100\, D_{w,Q}(z_{ref}) / PDD(z_{ref}) = \textbf{9,9840E-03} \text{ Gy / MU}$$

Notes:

[a] Note that if Q_0 is ^{60}Co, N_{D,w,Q_0} is denoted $N_{D,w}$

[b] All readings should be checked for leakage and corrected if necessary

[c] M in the denominator of k_{pol} denotes reading at the user polarity. Preferably, each reading in the equation should be the average of the ratios of M (or M_+ or M_-) to the reading of an external monitor, M_{em}.

[d] Check that $k_s - 1 \approx \dfrac{M_1/M_2 - 1}{V_1/V_2 - 1}$

$k_s - 1 =$ **0,003**

$\dfrac{M_1/M_2 - 1}{V_1/V_2 - 1} =$ **0,003** resty

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