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Measurement of the Radioactive Nuclides for the Medical Linear Accelerators based on the Spectroscopy using In-situ HPGe detector

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Severance

Activation in Linear accelerator (LINAC)

- **Purpose**
  - In the case of using X-ray energy above 8 MV, photoneutrons are generated by the photonuclear reaction
  - The components of the linear accelerator (LINAC) are **"ACTIVATED"**
- We measured the radioactive nuclides using an in-situ High Purity Germanium (HPGe) detector for the real-disposed LINACs and components.

Activation

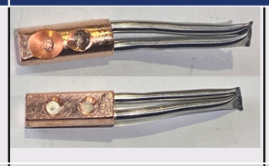
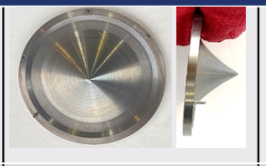
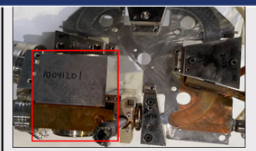
$${}^{A}_{Z}T_{N}(\gamma, n)^{A-1}_{Z}D_{N-1}$$

$${}^{A}_{Z}T_{N}(n, \gamma)^{A+1}_{Z}D_{N+1}$$

- **LINAC > 8 MV energy, Photo-nuclear reaction**
- **Neutrons react with "Target, Filter, Collimator, Jaw…"**
- **Components be activated**

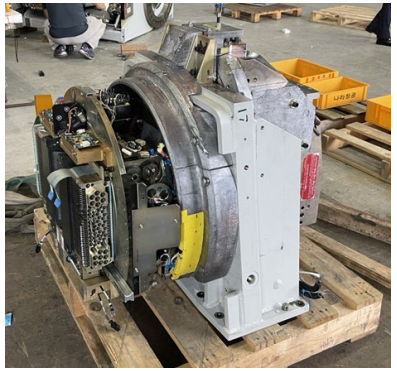
Spectroscopy

- ✓ **Spectroscopy (In-situ HPGe): The HPGe detector was positioned in front of the component and measured for 30 min for each component**
- ✓ **Targets for measurement: Disposed of LINACs (LINAC by Manufacturer: 1 Siemens, 2 Varian, 1 Elekta)**

Manufacturer		Varian 1 (15 MV)			Siemens (15 MV)		
Component							
Dose rate [μSv/hr]		15.6→2.21 *(5주 뒤)	4.10 → 2.37	2.43 → 2.49	26.9 → 7.05	6.97 → 3.64	7.65 → 7
*Half life > 100 days		Target	15 MV Filter	Primary Collimator	Target	15 MV Filter	Primary Collimator
^{51}Cr	27.70 d						
^{54}Mn	312.2 d						
^{57}Co	270.9 d						
^{57}Ni	35.65 h						
^{58}Co	70.80 d						
^{59}Fe	44.63 d						
^{60}Co	5.271 y						
^{64}Cu	12.70 h						
^{65}Zn	244.26 d						
^{99}Mo	66.02 h						
^{181}W	121.2 d						
^{184}Re	38.00 d						
^{187}W	23.83 h						
^{196}Au	6.183 d						
^{198}Au	64.80 d						

Spectroscopy

- The spectroscopy results for the LINAC “Varian 2” and “Elekta”, we couldn't figure the radio nuclides for the major components.
- LINAC Varian 2
  - → Institution where disposed Varian 2, used the 6 MV for 2 months before the disposal.
  - → Nuclides such as ^{60}Co or ^{54}Mn (long-lived radionuclide) was found from the lead block.
- LINAC Elekta
  - → We measured only for 10 min for the each components. (lack of the cps)



Trans-SPEC-DX-100T

GC2018

Surface dose rate measurement

Thermo FH 40 G-L10 survey meter

- ✓ We measured the surface dose rate for the each components using a survey meter
  - Measured the dose rate at the surface
  - Measured at the day of disposal & 5 weeks after disposal

* Surface dose rate (Major component such as Target, Primary collimator, flattening filter for high energy)

Surface dose rate [μSv/hr]	Target		Primary Collimator		Flattening filter (for High energy)	
point of the measurement	Day of disposal	5 weeks after disposal	Day of disposal	5 weeks after disposal	Day of disposal	5 weeks after disposal
Elekta	3.318	0.459 ~ 0.578	27.1	0.152	0.161	0.128
Siemens	26.856	7.0488	7.65	7.002	6.966	3.636
Varian 1	15.5	2.38	4.59	3.46	4.1	2.69
Varian 2	0.209	-	0.153	-	127.764	-

** Background dose rate was around ~ 0.125~0.135 μSv/hr*

* For the other components, such as Ion chamber, MLC, Jaw, dose rate was around background level.

4. Conclusion

- In this study, we measured immediate radionuclide analysis and dose rate evaluation using an In-situ HPGe detector and a survey meter for the medical LINACs.
- The difference in the level of radiation and the type of nuclide was confirmed depending on the period of use, energy, and workload.
- Therefore, in the process of relocating for the dismantling of the LINAC, it is considered to be safe exposure management when carried out 3 to 5 hours after stopping the operation.
- In future work, we will compare the nuclides acquired w/ Monte Carlo simulation.

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Thanks for the attention !